WATER GOES AROUND AND COMES AROUND

OBJECTIVES

The student will do the following:

1. Build a model of a water system from the source to users.

2. Learn to read and interpret a water meter.

3. Plan ways of water conservation at the community level.

SUBJECTS:
Science, Social Studies, Math

TIME:
120 minutes

MATERIALS:
large piece of cardboard
paper towel or bathroom tissue tubes
straws
different sizes of pasta (spaghetti, manicotti, etc.)
glue
paste or glue sticks
small boxes (matchboxes, small milk cartons)
markers
construction paper
student sheets (included)
teacher sheet (included)

BACKGROUND INFORMATION

It has been determined that each person in the United States uses about 150 gallons of water a day. Experts add the number of people who live in a city, town, or community, and multiply that number by 150 to determine how much water is used daily by that community.

People use water for drinking, cooking, bathing, flushing the toilet, laundry, washing cars, and watering lawns. Factories, farms, stores, public utilities, and homes use millions of gallons of water daily. It is a big job for water treatment facilities to supply clean drinkable water to a town, city, or community.

After the water treatment plant cleans the water, it sends it out to the users. As the water travels through a distribution system, it is diverted down different pathways to homes and businesses. The diameter of a pipe determines the quantity of water the pipe can hold and determines the rate the water can travel through the pipe. The volume of water needed for homes or businesses represents a small portion of the volume leaving the water plant. Therefore, smaller pipes are needed near the point of distribution, whereas larger pipes are needed near the treatment plant.

Water treatment plants pump water from a source (lake, river, or groundwater), treat the water, and pump it to holding tanks or water towers. If the water goes to a water tower, it flows by gravitational force from the water tower throughout the distribution system. Otherwise, water distribution is driven by motorized pumps.

Drinkable water is not free. Water treatment facilities and the distribution of drinking water are costly. Customers are charged according to the amount of water they use. A water meter is used to measure how many gallons (liters) or cubic feet (cubic meters) a household or business uses.

Because users pay for water and because there is only so much fresh water available for use, we must conserve our supplies, using them as wisely and efficiently as possible. We must not use water wastefully.

Many communities have already experienced shortages in water supplies due to lengthy droughts, growth in population that has outstripped the water system's capacity, or other problems. People in these communities have learned to eliminate unnecessary water uses.

Terms

community water cycle: the distribution of water from the source to user and back to the source.

water source: a place where water is collected and stored for use.

water meter: a device for measuring and recording the amount of water used.

ADVANCE PREPARATION

A. Gather materials for constructing the model. (NOTE: You may want to ask the students to bring in small boxes [matchboxes, milk cartons, etc.] to represent buildings in the community, or you may choose to use construction paper to draw and cut "buildings.")

   1. A large sheet of cardboard for each group to build model on.

   2. Paper towel tubes, straws, and pasta.

   3. The students may cut a river, stream, or lake from blue construction paper or draw this on the cardboard.

B. Prepare copies of student sheets and/or transparencies.

PROCEDURE

I. Setting the stage

Ask the students the following questions (which assume your students and school have water from a water utility):

A. How does the water that you drink get to your house? (It is piped from the river to the treatment plant, to a reservoir or storage tank, then to your homes.)

B. How does the water get to your school? (the same process)

C. What happens to the water when it leaves your home or school? (It goes to a wastewater treatment plant, then is discharged back to the river or lake.)

D. Where do people get water who do not live near water bodies and do not have city water systems? (wells) Where does wastewater from homes not connected to sewer systems go? (septic systems)

E. What do all these processes represent? (water cycles created by people)

F. Compare/contrast this human-created water cycle to the natural water (hydrologic) cycle. (The human water cycle comes from a lake or river, is distributed through the community, then goes to a treatment plant and back to the water supply. The hydrologic cycle is the movement of water from the atmosphere to the earth and its return to the atmosphere. Both cycles are continuous.)

G. Make very simple diagrams on the board to show a community water cycle and the natural water cycle.

II. Activities

A. Divide the students into groups of four or five and have each group build a model of your community water supply system from the source to the user.

1. Draw or cut from construction paper a river or lake and glue it to the cardboard.

2. Either draw houses and other buildings or construct them from small boxes to represent the community.

3. Show each group the illustration of the model of the water supply system to show them how to connect the "pipes" (paper towel tubes, straws, and pasta) with glue and lay them on the large piece of cardboard.

4. (Optional) The students may also show another set of "pipes" going to the wastewater treatment plant and returning to the source. (Use markers to color the wastewater lines a dark color.)

B. Ask the students the following questions:

1. How is the amount of water a home, school, or business uses measured? (A water meter measures the amount of water that is used so the customer can be billed correctly.)

2. Who reads the amount of water you use? (a meter reader from the water utility)

3. Explain to the students that water is not free and users must pay for its use. Water is paid for by the gallon (liter) or sometimes it is measured in cubic feet (cubic meters). What else is measured by the gallon (liter)? (gas, milk, juice)

C. Distribute the student sheet "Meet Your Meter" or you may want to use it as a transparency. Discuss and explain how to read a water meter. (You can get a meter face from your local water department. If you wish to concentrate on the meters most common in your community, call the billing department of your local water utility and ask about the meters where you live. Some people, like those who live in apartments, do not have individual meters. Their rent includes an estimated fee for water usage.)

1. The first meter is measured in gallons. Read and record the first meter that represents gallons. 103,836

2. The second meter measures water in cubic feet. Read and record this amount. 192,787

3. The third meter is read like a digital clock. Read and record this amount. 3,429

D. Ask the students to read the meters on the student sheet "Meter Reader" to reinforce the skill. The answers are: 1. 136,092; 2. 072,150; 3. 824,736.

IV. Extensions

A. Have students complete “Read Your Meter,” a take-home survey.

B. Brainstorm ways to conserve water.

1. List these suggestions on the blackboard or overhead projector.

   a. Check toilets and faucets for leaks.

   b. Keep a container of drinking water in the refrigerator.

   c. Turn off the water while you brush your teeth.

   d. Wash clothes only when you have a full load.

   e. Wash dishes only when you have a full load.

   f. Take shorter showers, or get a low-flow shower head.

2. Discuss the question, “Why should we conserve water?”

   a. Water is a natural resource that we all share.

   b. Wasting water wastes energy.

   c. Conservation will save money and make clean water supplies last longer.

C. Appoint a water patrol of 3 or 4 students to check bathrooms and water fountains for leaks or to see if they are left running. Report their findings to the janitor or principal.

D. The students may check the newspapers and clip out articles that concern water.

1. These may be placed on the bulletin board.

2. Students may write reports on their findings.

RESOURCES

Cobb, V., The Trip of the Drip, Little, Brown and Company, Boston, Massachusetts, 1986.

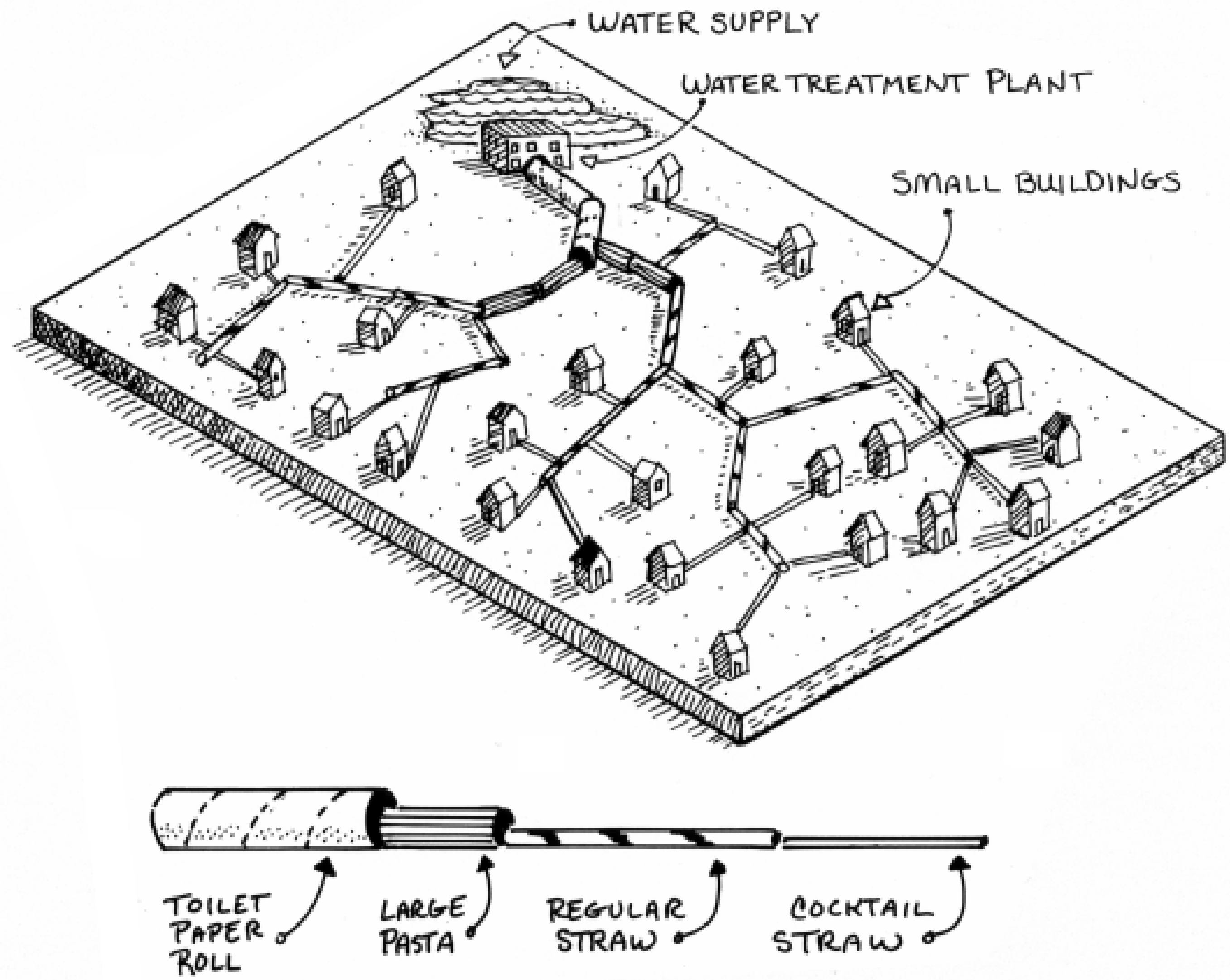
“Science Demonstration Projects in Drinking Water, Grades K-12,” U.S. Environmental Protection Agency, Washington, DC, 1990.

“The Story of Drinking Water” (student booklet), American Water Works Association, Denver, Colorado, 1984.

“The Story of Drinking Water: Teacher’s Guide, Intermediate Level, Grades 4, 5, 6,” 2nd ed., American Water Works Association, Denver, Colorado, 1988, pp. 23-24.

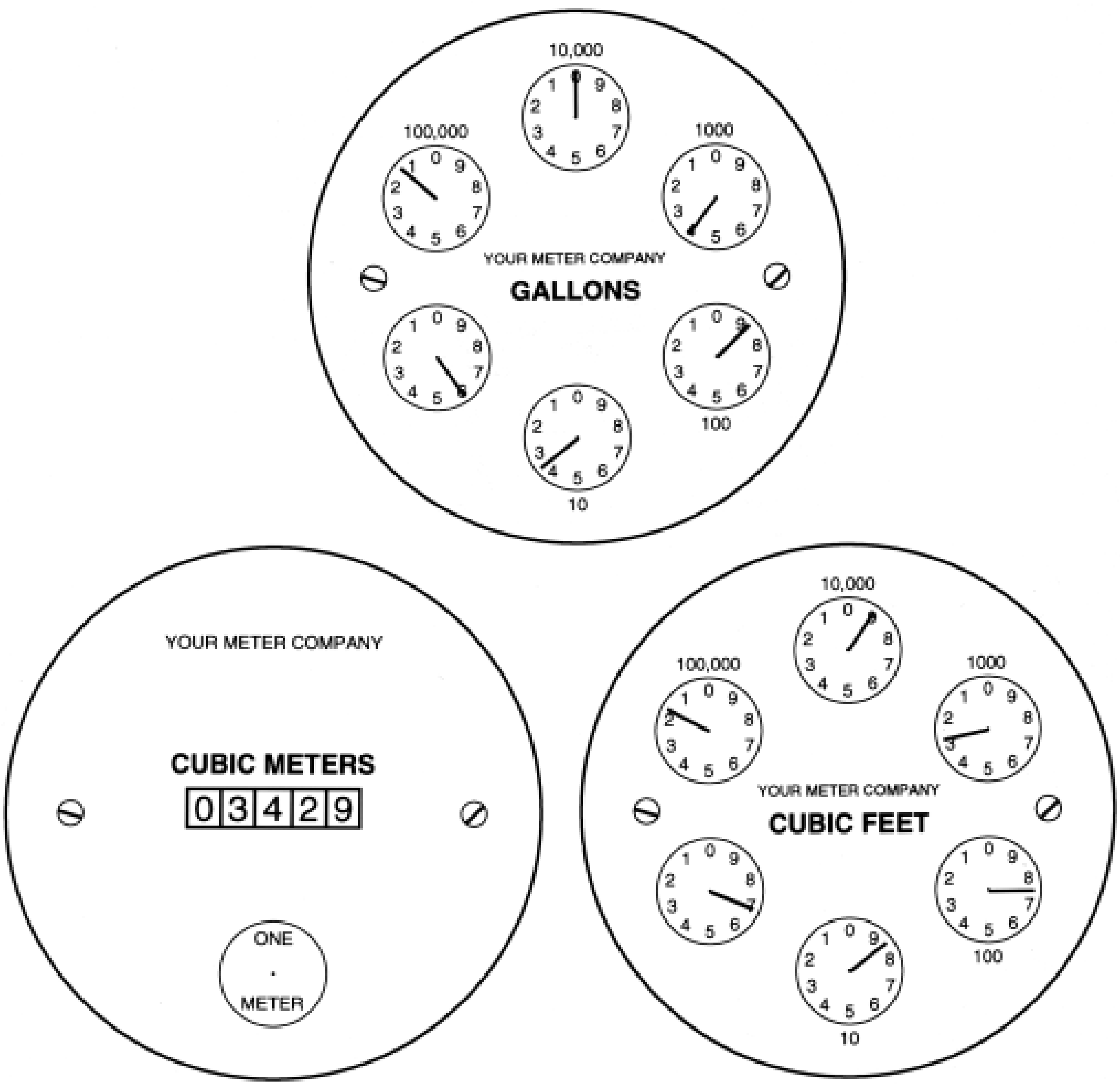
Student Sheet

COMMUNITY WATER SUPPLY SYSTEM MODEL



MEET YOUR METER

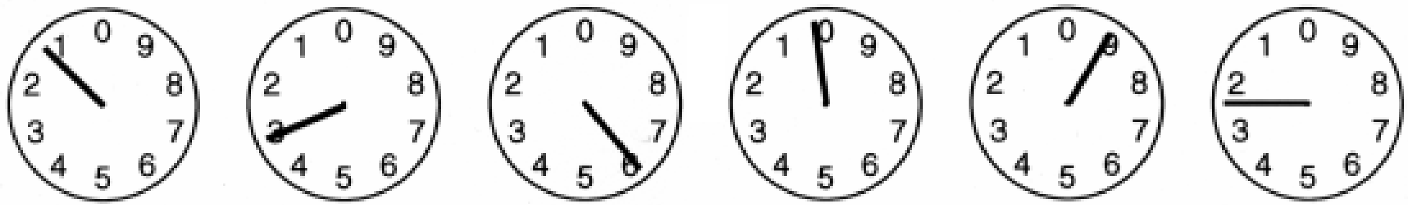
Your water meter probably looks like one of these. The first meter is read clockwise and measures water in gallons. The second meter measures water in cubic feet and is read in the same manner. (To convert cubic feet to gallons you must multiply the number on the meter by 7.5.) The third meter is read like a digital clock. Meters 1 and 2 have six dials, which are read clockwise. Begin with the "100,000" dial and read each dial to the "1" dial. Remember that when the dial is between two numbers, you read the smaller number.



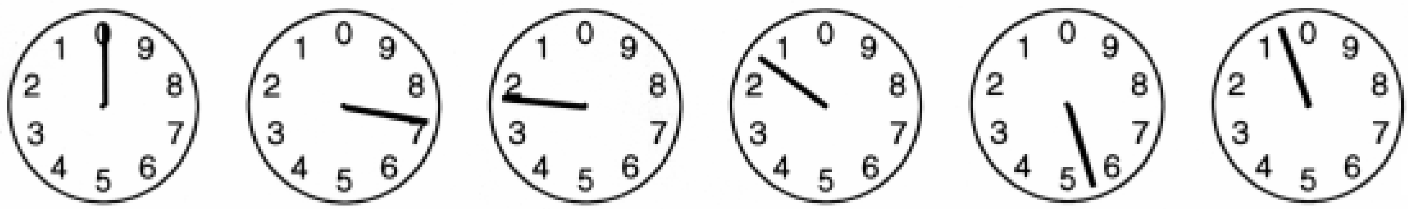
METER READER

Directions: Read the dials from left to right. When the dial is between two numbers, read the samller number. Write the numbers in the blanks below the dials.

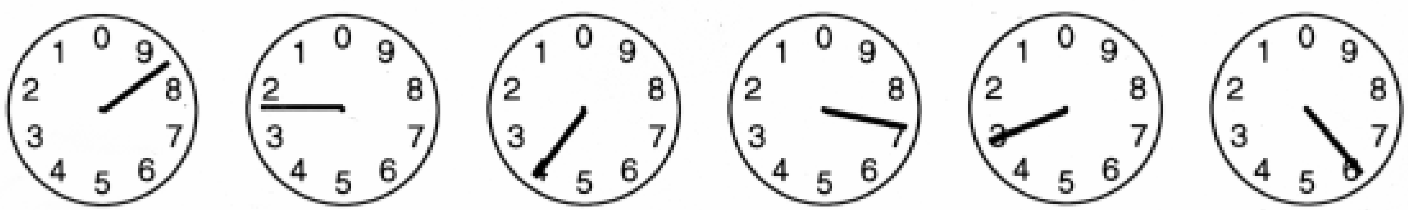
1.



2.



3.



READ YOUR METER

1. Does the meter at your home measure water in gallons or cubic feet? ________

2. Does your meter at home have a single dial (odometer- digital type) or a solid dial meter (like the three you read on the other student sheet)? ____________

3. Which type of water meter does the school have? ____________ How can you find out? ____

4. How many of gallons of water were used in your home last month? (Ask your parents to show you the water bill.) ____________

5. How many days were in the billing period?____________

6. What was the average number of gallons your family used per day? (Divide the total number of gallons of water used by the number of days in the billing period.)

7. Find your meter at home and read your meter every day for the next week. If you don't have a meter at home, check with the janitor to see if you can read the meter at school.

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Date							
Reading							
Daily Units							
Add all the daily units for your weekly total:						Weekly Total	

8. What was your family's average daily use? Add the weekly total, then divide the weekly total by the total number of readings (7).

9. Compare the daily average with the daily units. What did you find out? ______
____

10. What day of the week did your family use the most water? ____________
What day did they use the least? ____________________

WATER WORKS

OBJECTIVES

The student will do the following:

1. Demonstrate the process that water treatment plants use to purify water for drinking by conducting a water purification experiment.

2. Describe what happens in the water treatment process by writing a story.

SUBJECTS:
Science, Social Studies, Language Arts

TIME:
120 minutes

MATERIALS:
1 gallon (4 L) jug of water
2 1/2 cups (600 mL) soil or mud
acetate sheet
four 2-liter plastic bottles
funnel
scissors
2 tablespoons (30 mL) of alum
2 tablespoons (30 mL) of bleach
2 cups (500 mL) fine sand
2 cups (500 mL) coarse sand
1 cup (250 mL) fine gravel
1 cup (250 mL) coarse gravel
1 cup (250 mL) activated charcoal
cotton for plug
tap water
a tablespoon
clock
student sheets (included)
tape recorder with tape (optional)
camera with film (optional)
teacher sheet (included)

BACKGROUND INFORMATION

Water treatment is the process of cleaning water and making it safe for people to drink. Because water is a good solvent it picks up all kinds of contaminants. In nature, water is not always clean and safe enough for people to drink.

Our drinking water comes from both surface and groundwater. Water in lakes, rivers, and swamps contains impurities that may make it look and smell bad. Water that looks clean may contain harmful chemicals or bacteria and other organisms that can cause disease.

In the past, waterborne diseases were a major public health concern but today these diseases are no longer a health threat in the United States because of the improved water treatment. Technicians working in drinking water facility laboratories make thousands of tests each year to insure that our drinking water supply is free of disease-causing bacteria. These test results are reported to the state and local governments.

It takes the efforts of both federal and state governments as well as local water supply systems to keep our drinking water safe and in good supply. The Safe Drinking Water Act and its amendments set the standards for public drinking water. The Environmental Protection Agency administers these standards.

Water treatment plants clean and maintain the quality of drinking water by taking it through the following processes: (1) aeration, (2) coagulation, (3) sedimentation, (4) filtration, and (5) disinfection (see definitions in "Terms" below).

Terms

aeration: to expose to circulating air; adds oxygen to the water and allows gases trapped in the water to escape; the first step in water treatment.

coagulation: the process by which dirt and other suspended solid particles are chemically "stuck together" so they can be removed from the water; the second step in water treatment.

disinfection: the use of chemicals and/or other means to kill potentially harmful microorganisms in the water; the fifth step in water treatment.

filtration: the process of passing a liquid or gas through a porous article or mass (paper, membrane, sand, etc.) to separate out matter in suspension; the fourth step in water treatment.

groundwater: water that infiltrates into the earth and is stored in usable amounts in the soil and rock below the earth's surface; water within the zone of saturation.

sedimentation: the process that occurs when gravity pulls particles to the bottom of the tank; the third step in water treatment.

sludge: solid matter that settles to the bottom of septic tanks or wastewater treatment plant sedimentation tanks; must be disposed of by bacterial digestion or other methods or pumped out for land disposal or incineration.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans.

water treatment: a method of cleaning water for a specific purpose, such as drinking.

ADVANCE PREPARATION

A. Make a copy of the diagram of a water treatment plant and water treatment word search puzzle for each student. You may use the diagram of a water treatment plant as a transparency.

B. Gather materials for demonstration of water treatment process.

C. Prepare "dirty water"; add approximately 2 1/2 cups (600 mL) of soil or mud to 1 gallon (4 L) of water.

D. Cut one 2-liter bottle in half, cut the bottom from another bottle, and cut the top from a third bottle.

E. Alum can be found at the grocery store in the spices section. It is commonly used for making pickles.

F. NOTE: You may want to construct the filter before beginning the activity or may choose to let a team of students prepare it. To prepare the filter use the bottle with its bottom cut off to construct the filter. Turn the bottle upside down. Loosely put a cotton plug in the neck of the bottle. Pour the fine sand over the cotton plug followed by activated charcoal, coarse sand, fine gravel, and coarse gravel. Clean the filter by slowly and carefully pouring through 1-2 gallons (4-8 L) of clean tap water.

PROCEDURE

I. Setting the stage

A. Ask the students the following questions.

1. How many of you used water in some way today?

2. How did you use water? (shower, brush teeth, flush toilet, prepare meal)

3. Where does your water come from?

4. How can you be sure your water is safe to drink?

B. Discuss the water treatment plant and what it does.

1. Hand out the diagram of a water treatment plant.

2. Discuss the process that takes place during each step. Use the definitions given to explain each step:

a. Aeration – Vigorously stirring up water to add air to it and drive out other gases that might be dissolved in it; similar to "whipping" it with a mixer (as in cooking).

b. Coagulation – Adding chemicals to make dirt and other particles clump together.

c. Sedimentation – Letting the clumps settle out (they're heavier than water, so they sink to the bottom).

d. Filtration – Pouring the water through a filtering system that has lots of layers of materials that trap things that did not settle out (including things too small to see).

e. Disinfection – Adding chlorine to kill germs that might make people sick (similar to swimming pool methods).

3. Write the letters A, C, S, F, and D on the board. Review with the students the words they stand for. Write simple-to-remember phrases for each one, such as:

a. A = Add air

b. C = Create clumps

c. S = Soil settles out

d. F = Fine filters to trap tiny things

e. D = Die, germs, die!

Leave these on the board while the class builds the model.

II. Activities

A. Review the diagram of the water treatment plant. Discuss with the students, checking for understanding. Allow for questions and comments from the students.

B. Divide the students into teams of four or five students. Each team will perform one step in the process. (Supervise closely.) Give Team I the materials and dirty water to start.

   1. Team I should pour about 1.5 quarts (1.6 L) of "dirty water" into the uncut 2-liter bottle with the cap. (Use a funnel) Ask the students to describe the water.

   2. Have a student in Team I put the cap on the bottle and shake for 30 seconds. Continue the aeration process by pouring the water back and forth between two bottles 10 times. Ask the students what part of the water treatment process we have demonstrated. (aeration) Ask the students to describe any changes they observe.

   3. Team II should pour the aerated water into the 2-liter bottle with the top cut off. Add 2 tablespoons (30 mL) of alum to the water. Stir the mixture slowly for 5 minutes. Ask the students what process this group has demonstrated. (coagulation) Ask the students to predict what will happen.

   4. Team III should allow the water to stand undisturbed for 20 minutes. Ask the students to observe the water at 5 minute intervals and record their observations as to changes in the appearance of the water. (NOTE: Other groups may do the student sheet word search during this time frame or Team IV may construct the filter from the bottle with its bottom cut off. If you prefer to construct the filter model yourself, you may do it now if you'd like.) Ask the students what step this is? (sedimentation)

   5. Team IV should carefully, without disturbing the sediment, pour the top two-thirds of the water through the filter. Ask the students what step this is. (filtration) Have them quickly rest the filter model in the 2-liter bottle cut in half to collect the filtered water.

   6. After waiting until you have collected more than half of the water poured through the filter, add 2 tablespoons (30 mL) of bleach to the filtered water. The bleach represents the chlorination process. (CAUTION: Wear eye protection when handling bleach and quickly wash it off your skin if some should splash.) This is <u>disinfection</u>. Ask the students: "Did we recover the same amount of water we started with?" Measure approximately. Discuss that there is a certain loss of usable water in the water treatment process.

C. Compare the treated and untreated water.

   1. Ask the students whether treatment has changed the appearance and smell of the water. How has it changed?

   2. Explain to the students that this is a simulation of the process that a water treatment plant does; therefore, this water is <u>not</u> safe to drink.

III. Follow-Up

A visit to the local water treatment plant is a valuable experience. If this is not possible, ask a representative from the water utility to visit the class.

A. As you tour the plant, use your A, C, S, F, and D memory devices to review the terms with the students.

B. Assign each student a responsibility to perform during the trip or visit. Develop assignments and questions in advance. You may use the student sheet, “Water Works.”

C. Send the contact person at the water treatment plant a copy of the assigned questions before the visit so he/she will be prepared for the group.

D. One student could also tape record the experience and another student could take photos for a visual record.

IV. Extensions

A. Have the students write a story or draw cartoons about “Betty Bacterium,” “Sediment Sam,” or other fictional characters and describe what happens to these characters as they go through the water treatment process.

1. Share the stories/cartoons with the class.

2. Use as a bulletin board activity to reproduce the water treatment process.

B. Ask the students to do the student sheet “Water Treatment Words” if you did not use it in the activity.

The answers to the word search are as follows:

```
a g b f o n i f g r o u n
r g r v u t s i d a o n i
d i c o a g u l a t i o n
s e n f u u n t t r a t s
m n s t a n a r t e f s a
u m n r u x d a r a s t e
s u r f a c e t n t i o r
m r t a f a c i l m s n a
s w a t e r a o a e o x t
n e b a v l o n m n a o i
b a e t o n b a c t t e o
s e d i m e n t a t i o n
a e l r o u s m f g o n t
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RESOURCES

“Science Demonstration Projects in Drinking Water: Grades K-12,” U.S. Environmental Protection Agency, Washington, DC, 1990.

“The Official Captain Hydro Water Conservation Workbook,” East Bay Municipal Utility District, Oakland, California, 1982.

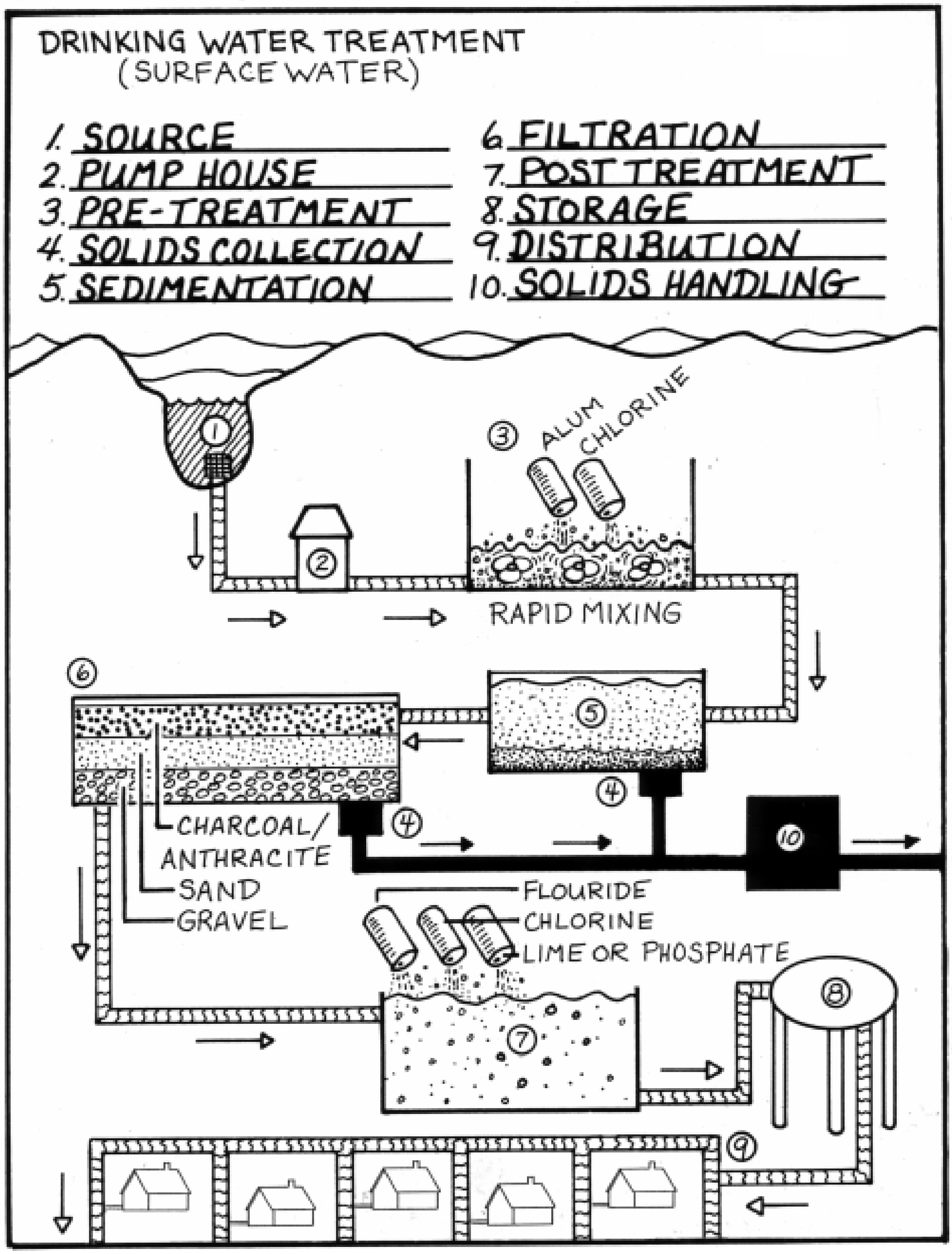
“The Story of Drinking Water” (student booklet), American Water Works Association, Denver, Colorado, 1984.

“The Story of Drinking Water: Teachers Guide, Intermediate Level, Grades 4, 5, 6,” 2nd ed., American Water Works Association, Denver, Colorado, 1988.

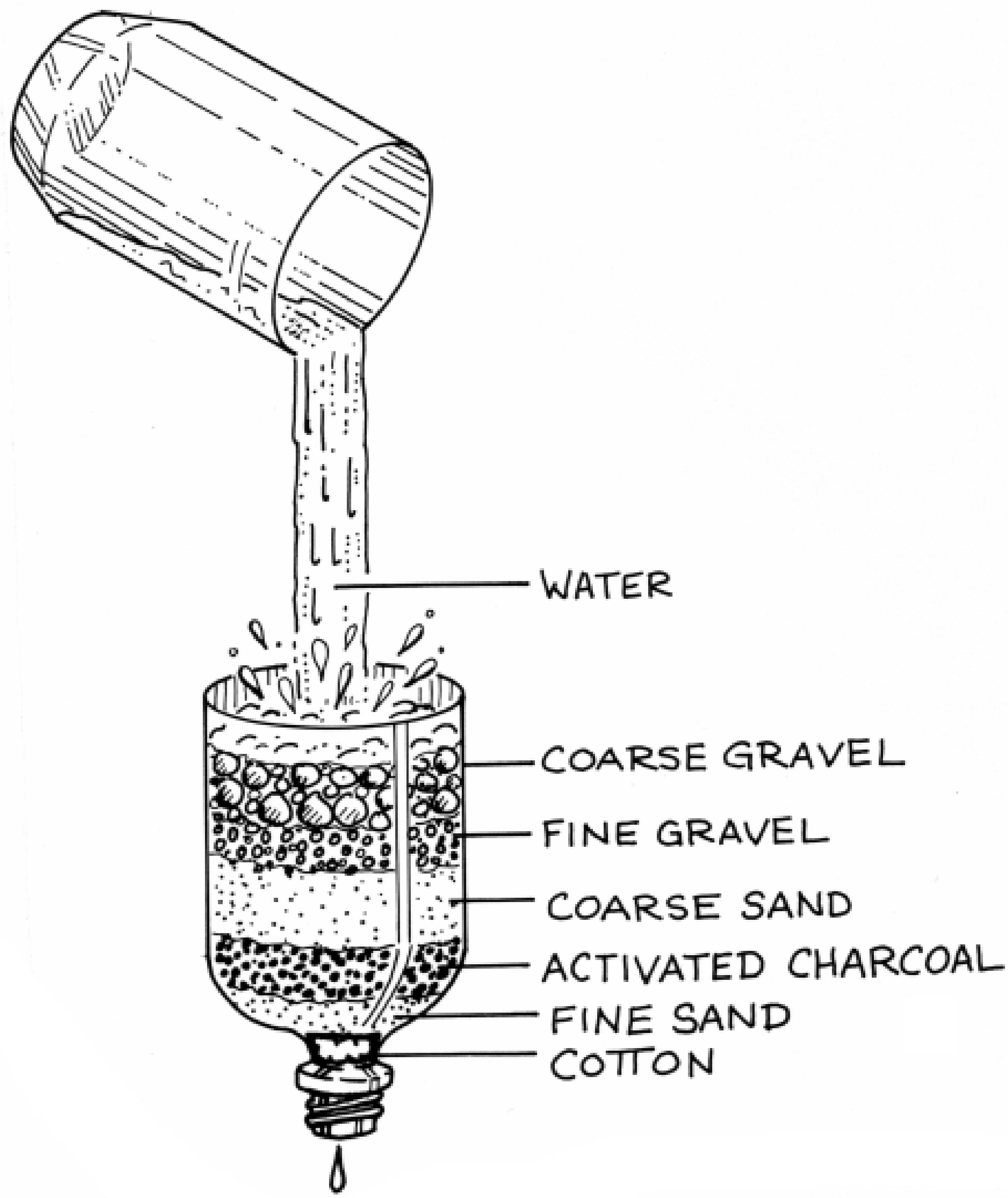
Student Sheet

DRINKING WATER TREATMENT PLANT

Student Sheet



FILTER MODEL



Answer the following questions.

1. Where does our water come from?

2. How much clean water is produced each day?

3. How is the water tested?

4. What is used to destroy bacteria in the water?

5. What are the future plans for the water treatment system? As our community

Can you find these words? Find the words, circle them, and check them off the list.

aeration	water	surface
coagulation	treatment	ground
filtration	sedimentation	

a	g	b	f	o	n	i	f	g	r	o	u	n
r	g	r	v	u	t	s	i	d	a	o	n	i
d	i	c	o	a	g	u	l	a	t	i	o	n
s	e	n	f	u	u	n	t	t	r	a	t	s
m	n	s	t	a	n	a	r	t	e	f	s	a
u	m	n	r	u	x	d	a	r	a	s	t	e
s	u	r	f	a	c	e	t	n	t	i	o	r
m	r	t	a	f	a	c	i	l	m	s	n	a
s	w	a	t	e	r	a	o	a	e	o	x	t
n	e	b	a	v	l	o	n	m	n	a	o	i
b	a	c	t	o	n	b	a	c	t	t	e	o
s	e	d	i	m	e	n	t	a	t	i	o	n
a	e	l	r	o	u	s	m	f	g	o	n	t

WILL THAT HOLD WATER?

OBJECTIVES

The student will do the following:

1. Be aware of and discuss the five major purposes of dams.

2. Locate on a U.S. map the dams listed on the student sheet on the history of dams.

3. Build and test a model of a specific type of dam assigned to their team.

SUBJECTS:
Geography, Science, Art

TIME:
3 45-minute periods

MATERIALS:
5 half-gallon (2 L) cartons
6-8 quarter-inch (0.6 cm) dowel rods
glue
craft sticks
gravel
clay (ask the art teacher for some clay or you can use the cooked play dough recipe on teacher sheet)
teacher sheets (included)
paper towels
water
aluminum foil or aluminum pie pans
student sheets (included)
graph paper (optional)
paper cups (optional)
potting soil (optional)
bean seeds (optional)
plastic tray (optional)

BACKGROUND INFORMATION

People have built dams for thousands of years. Even earlier, beavers were damming streams to change their environment. Before 1905 no dam in the U.S. was taller than 200 feet. Fifty years later 159 dams 200 feet high or higher had been completed. Modern dams are designed to be multi-purpose dams. Their five major purposes are: water supply, irrigation, flood control, electric power production, and recreation. The lake created by damming a stream or river is called a reservoir. Some of the most famous dams in the U.S. are Hoover Dam in Arizona-Nevada; Grand Coulee Dam in Washington; Shasta in California; Bonneville in Oregon; Flaming Gorge in Wyoming-Utah; Kentucky Dam in Kentucky; Norris Dam in Tennessee; and Wheeler Dam in Alabama.

Hydroelectric dams use the energy of falling water from reservoirs to produce electricity by the use of turbines and generators. Hydroelectric power is non-polluting because it uses no fossil fuels and is non-consuming because it uses a renewable resource. (However, dams must be carefully planned so that they do not unnecessarily damage ecosystems when they flood an area and cause changes in the rivers they dam.)

<u>Terms</u>

dam: a wall-like barrier across a stream or river to stop the flow of water.

drought: period of less-than-normal rainfall.

hydroelectricity: electricity produced by the power of falling water striking a turbine and turning a generator.

flood: period of more-than-average rainfall.

reservoir: a body of water stored in a natural or artificial lake.

ADVANCE PREPARATION

A. Cut one side and the top off of 5 half-gallon (2 L) cartons (or plastic milk jugs).

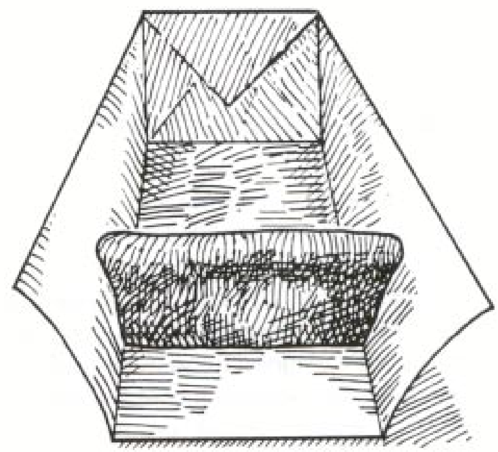
B. Cut 6-8 quarter-inch (0.6 cm) dowel rods into 3-inch (7.5 cm) pieces.

C. If you cannot get pottery clay, mix up 5 batches of the salt dough recipe and keep in an airtight bowl (see teacher sheet "Salt Dough Recipe").

D. Copy the student sheets "History of Dams," "Types of Dams," and "Will It Hold?"; make one per student.

E. Write the names of the 5 types of dams (rock, timber, embankment, masonry, and concrete) on slips of paper and put them in a cup.

F. Gather sticks, gravel, and other dam-building materials such as aluminum foil or aluminum pie pans.



PROCEDURE

I. Setting the stage

A. Begin the discussion by asking the class these questions:

1. What happens sometimes when it rains too much? (It floods. Write "flood" on the board and define.)

2. What happens when it doesn't rain enough? (There is a drought and plants and crops die. Write "drought" on the board and define.)

3. Is there anything people can do to keep it from flooding and to save water to use during droughts? (We can build dams. Write "dam" on the board and define. If some students are not familiar with dams, draw a simple diagram on the board showing that a dam blocks the flow of a river and causes a lake – reservoir – to fill up behind it. The dam has passageways in it through which we allow some water to pass, so there is still a river.)

B. Tell the class they are going to learn about dams and what dams do for people.

1. Pass out the "History of Dams" student sheet and ask for volunteers to read it.

2. List the five purposes of dams on the board. For each (water supply, irrigation, flood control,

electric power production, and recreation), give an explanatory comment about how dams accomplish these things.

3. List the types of dams (earthen, rock, timber, embankment, masonry, and concrete) on the board.

4. List the famous U.S. dams on the board.

5. Ask for volunteers to locate them on a large U.S. map.

II. Activity

A. Begin the dam-building experiment.

1. Divide the class into five even teams (e.g., 5 teams of 5 for 25 students).

2. Explain that each team will be assigned to build a model of one type of dam. The class will build all but the earthen dam. You will provide clay, sticks, gravel, and other materials. They must determine how to use these to simulate the materials shown on the diagrams.

3. Pass out the "Will It Hold?" student sheet and have each team predict which dam will last the longest. (NOTE: You may elect not to do the formal experimentation, but to simply have the groups build and demonstrate the models.)

4. Have each team draw one slip of paper from the cup to see which model they will make.

B. Re-arrange the students' seating into teams (cooperative learning groups) and do the following:

1. Pass out the "Types of Dams" student sheets to each team and have them study the diagram of the dam they will build.

2. Each team should have a record technician, a time technician, a supply technician, a water technician, and a group leader. Let the students choose their roles.

3. The team will plan together how to build their dam. The record technician should record the plan in steps.

4. The supply technician will go to the supply table and get the needed materials for their team.

5. You will be available for technical advice, but should not physically help teams.

C. Once all dams are complete, they must dry for 5-7 days, after which testing will begin. (NOTE: You may omit the testing in step 2 and use the models for demonstration and display only.)

1. The water technician will slowly pour water behind the dam.

2. The time technician will call time intervals while the data technician records information. Data will be recorded every 15 seconds for the first 2 minutes and then every 2 minutes for the next 8 minutes.

III. Follow-Up

A. Each team will graph their data from their experiment. The graphs can be used to make a bulletin board display on the strength of dams.

B. If you have omitted the testing, have each group draw a large diagram of their type of dam. (Supply the butcher paper and art supplies.) Display these drawings.

C. An excellent follow-up would be a field trip to a nearby dam. Ask the contact person at the dam to talk to your students about how and why the dam was built.

IV. Extensions

A. For lower grades, do a seed growing experiment. Discuss with the class how sometimes there is too much water (flooding) and sometimes there is not enough water (drought). In teams do the following:

1. Pass out three cups to each team and poke a small hole in the bottom with the pencil.

2. Number the cups 1-3.

3. Fill the cups with potting soil.

4. Plant three bean seeds in each cup.

5. Put all cups on the plastic tray.

6. Do the following every day:

    a. Do not water #1

    b. Water #2 until the soil is damp

    c. Water #3 until a layer of water covers the soil.

7. Keep the cups in a sunny window.

8. Keep a journal on what changes happen each day. (NOTE: The beans in #2 should sprout in about a week.)

9. Ask the students "Why didn't the beans in cups #1 and #3 sprout?" Relate this to how dams help control the amount of water available for us to use: They prevent water shortages and floods.

B. For higher grades have students investigate beaver dams and their impact on the environment. See teacher fact sheet "Beavers and Their Dams."

RESOURCES

Arnold, Caroline, Bodies of Water: Fun, Facts, and Activities, Franklin Watts Publishing Co., New York, 1985.

"Dams," Encyclopedia Americana, Grolier, Inc., Danbury, Connecticut, 1987.

Hunt, Bernice K., Dams: Water Tamers of the World, Parents' Magazine Press, New York, 1977.

Miller, James E., "Beavers", Program Leader, Fish & Wildlife, USDA - Extension Service, Natural Resource and Rural Development Unit, Washington, DC, 1983.

Teacher Sheet

SALT DOUGH RECIPE

In a heavy sauce pan mix the following ingredients together:

1 cup (250 mL) plain flour
1/2 cup (125 mL) salt
2 tsp (10 mL) cream of tartar

Add the following:

1 cup (250 mL) water
1 tbs (15 mL) cooking oil
oil of wintergreen (optional)

Stir all together and cook at low temperature for 3 minutes or until it pulls away from the sides of the pan.

Almost immediately, knead lightly and store in an airtight container. You may add a few drops of oil of wintergreen to help the aroma.

It will take about a week for this to dry.

Make one batch for each team.

Student Sheet

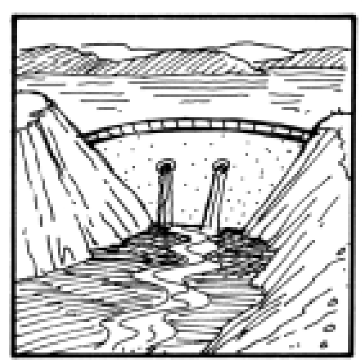
HISTORY OF DAMS

The first dam builders were beavers. Beavers build dams to change their environment more to their liking. People followed the beavers' lead and began building dams thousands of years ago to control and change their environments, to hold water, to control flooding, and to use water power.

The earliest reported dam was built on the Nile river about 5000 years ago to control flooding. Ancient dams were built to control flooding, provide drinking water, and supply water for irrigation. The Kaerumataike Dam in Japan is 2200 years old and is still used today. A dam on the Prontes River in Syria built 3300 years ago is still being used. The Romans built dams throughout their empire to control the water supply.

After the fall of the Roman Empire, dam-building ceased until it was reborn as a science during the 19th century. Modern dams are designed to be multi-purpose. The five major purposes of dams are water supply, irrigation, flood control, electric power production, and recreation.

In a fifty-year period of time ,159 dams 200 feet high or higher were built in the United States. Some of the most famous dams in the U.S. are: Hoover Dam in Arizona-Nevada, Grand Coulee Dam in Washington, Shasta in California, Bonneville in Oregon, Flaming Gorge Dam in Wyoming-Utah, Kentucky Dam in Kentucky, Norris Dam in Tennessee, and Wheeler in Alabama.



Modern dams are built to provide water supplies, protection from floods, and hydroelectric power, as well as for other purposes. Hydroelectric power is non-polluting because it uses no fossil fuels and is non-consuming because it uses a renewable resource.

Name ______________________

Date ______________

WILL IT HOLD?

I. Predictions

1. Which type of dam will be less likely to leak?

2. Which type of dam will last the longest?

____

II. Building Plan (Record here.)

____

III. Testing (Record Observations)

15 seconds

105 seconds

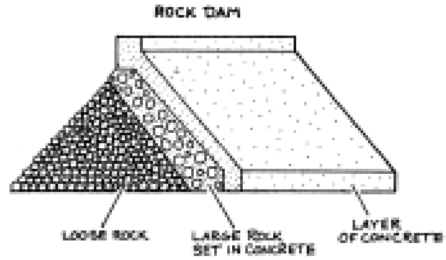
30 seconds

2 minutes

45 seconds		4 minutes	
60 seconds		6 minutes	
75 seconds		8 minutes	
90 seconds		10 minutes	
			Student Sheet

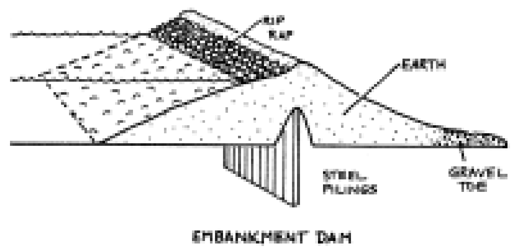
TYPES OF DAMS

The earliest dams were made of earth an(are called earthen dams. Earthen dam: are sometimes the most practical eve today. Some other kinds of dams are roc dams, timber dams, embankment dams masonry dams, and concrete dams.

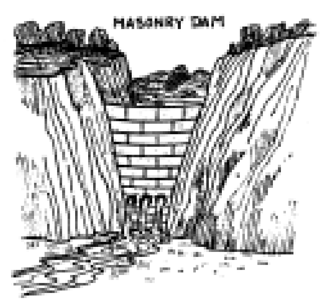


Rock dams are used in rocky areas. Ofte a concrete facing is added to a rock dam

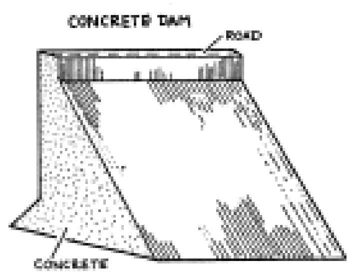
Timber dams are made of tightly fittin planks of wood supported and held to gether by rocks.



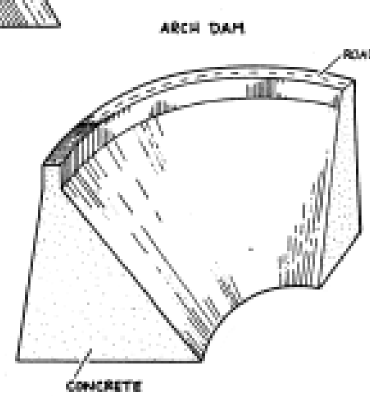
Embankment dams are good for dammin broad streams. They are made by heap ing up earth, clay, and gravel and the pressing it down until it is packed an watertight. The top layer is close-fittin stone called riprap.



Masonry dams were used to dam narrov streams running through mountain gorges They are made with blocks of stone o concrete. Masonry dams are not good fo broad streams but may be built extremel high.



Concrete dams can be built in many differ ent shapes such as a gravity dam, buttres dam, or multi-arch dam.



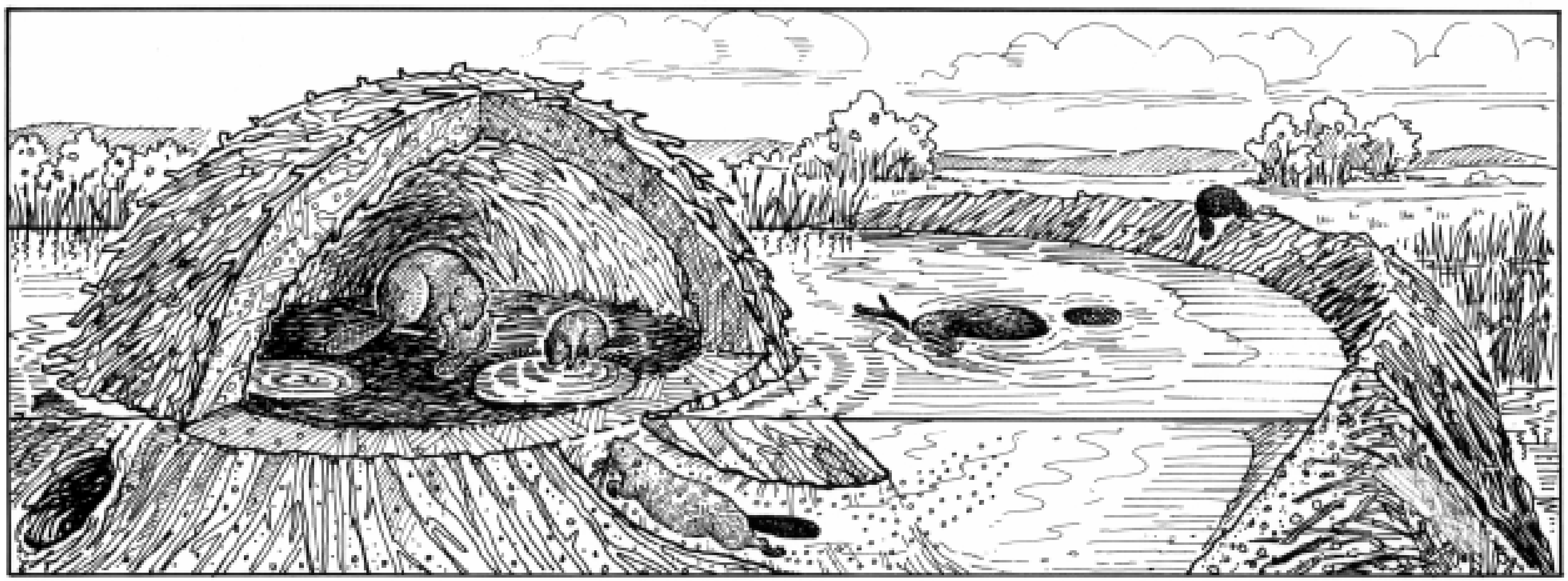
Dams must be built thicker at the bottor than the top so that they can stand up to th high pressure exerted by the water.

BEAVERS AND THEIR DAMS

Beavers love water. They live where there is a your-round source of water. They live in streams, lakes, ponds, swamps, wetlands, roadside ditches, canals, mine pits, drains from sewage disposal ponds, and below natural springs. Once beavers move into an area they quickly begin building dams to modify the environment to their liking.

Beavers build their dams with logs, branches, and twigs from trees they cut down and with mud from the stream or lake. Beavers eat the trees as well as use them for building material. The size of a beaver dam can vary greatly. In some areas a dam may not be more than 36 inches (65 cm) high even though it may be one -quarter mile (0.4 km) long. In a mountainous area, a dam might be 10 feet (3 m) high and only 50 feet (15 m) wide.

A lodge or bank den is also built into the dam. The den is used for raising young, sleeping, and fod storage. Beaver dens always have at least two entrances, and some have four or more.



THE INVISIBLE WATER SOURCE

OBJECTIVES

The student will do the following:

1. Identify various sources of drinking water.

2. Relate the water cycle to water supply.

3. Demonstrate the presence of water in a cloud.

SUBJECT:
Science, Art, Social Studies

TIME:
45 minutes

MATERIALS:
map of your state (1 for each student)
large jar
plastic bag of ice (to fit over the jar opening)
a sheet of black paper
flashlight
2 chalkboard erasers (used)
matches (for teacher use only)
blue markers or crayons

BACKGROUND INFORMATION

Water is a familiar substance. We drink it, wash with it, swim in it, and sometimes grumble when it falls from the sky. We are so accustomed to water that most of us are unaware that it is among the rarest and most unusual substances in the universe. Our planet has a vast supply of water but only a tiny fraction is readily available for use by people.

Most of the earth's surface is covered with water. More than 70 percent of the human body is water. Water is essential to all plant and animal life. No organism can live without it. So water supply and quality are critical. Much of our water supply is visible in the form of surface water in oceans, lakes, streams, rivers, and glaciers. Much of our water supply is unseen, as it is groundwater. Groundwater may be trapped in rock or sand formations or flow through porous rock or even underground rivers. The ability to access groundwater supplies through wells or springs is vital to the development of some areas. Deserts have been transformed into vital agricultural areas using groundwater resources. Today, the amount of water on earth remains the same as it always was!

<u>Terms</u>

groundwater: water that infiltrates into the earth and is stored in usable amounts in the soil and rock below the earth's surface; water within the zone of saturation.

river: a large natural stream of water emptying into an ocean, lake, or other water body.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans.

water: a transparent, odorless tasteless liquid, composed of hydrogen and oxygen.

ADVANCE PREPARATION

A. Maps of your state can be obtained from state social studies resource books. Road maps are a good source to use as outline maps. Universities have cartography labs that can help supply outline maps, and state water resource departments can also supply maps.

B. Place a jar on black paper or tape the paper to the back of the jar so you can't see through it. Fill 1/3 full with warm water. (NOTE: If a hot plate or source of heat is available, it can be used to keep the water warm until it is used.)

C. Have the bag of ice and matches nearby.

PROCEDURE

I. Setting the stage

A. Brainstorm with the students about areas of the world where they know there is water.

B. Ask the students where they have seen water in your state (rivers, oceans, rain, faucets, etc.). Write these sources (at least 10-15) on the board. Write specific names if they know them (e.g., Mississippi River).

C. Decide with the class which ones they could drink if they were thirsty. Erase the nondrinkable ones after discussing possible reasons why (e.g., ocean water is too salty to drink).

D. Ask the students if they know why the drinking water sources do not get used up even though people use them all the time. (They are renewed by the water cycle.)

II. Activities

A. Distribute maps of your state.

1. Have the students color all areas mentioned as water sources blue.

2. Explain that the areas colored blue are called "surface waters."

3. Explain that some of the areas not colored contain water underground that is called groundwater. Discuss ways people get water out of the ground, such as wells and springs.

B. Briefly review the water cycle to show that water is also present in the air. Help students comprehend that rainwater is not a drinking water source but feeds the surface waters and groundwater. If need be, draw a diagram of the water cycle on the board to remind students of how it works.

C. Point out to the students that there is a lot of (invisible) water in the atmosphere, as well as under the ground. (In fact, there is nearly 50 times more water in the atmosphere than in our fresh surface waters, and about 100 times more water underground than in those "blue waters.")

D. Explain that a cloud occurs when the invisible water vapor in the air becomes visible water droplets or ice crystals.

1. Clap two used erasers together.

   a. Have a student shine the flashlight into the dust "cloud."

   b. Explain that these chalk particles are similar to the dust particles that help form clouds.

2. Make a cloud in a jar. Place the jar on black paper or tape the paper to the back of the jar. (This helps make the cloud more visible. The method used will depend on the number and location of your students during the activity.)

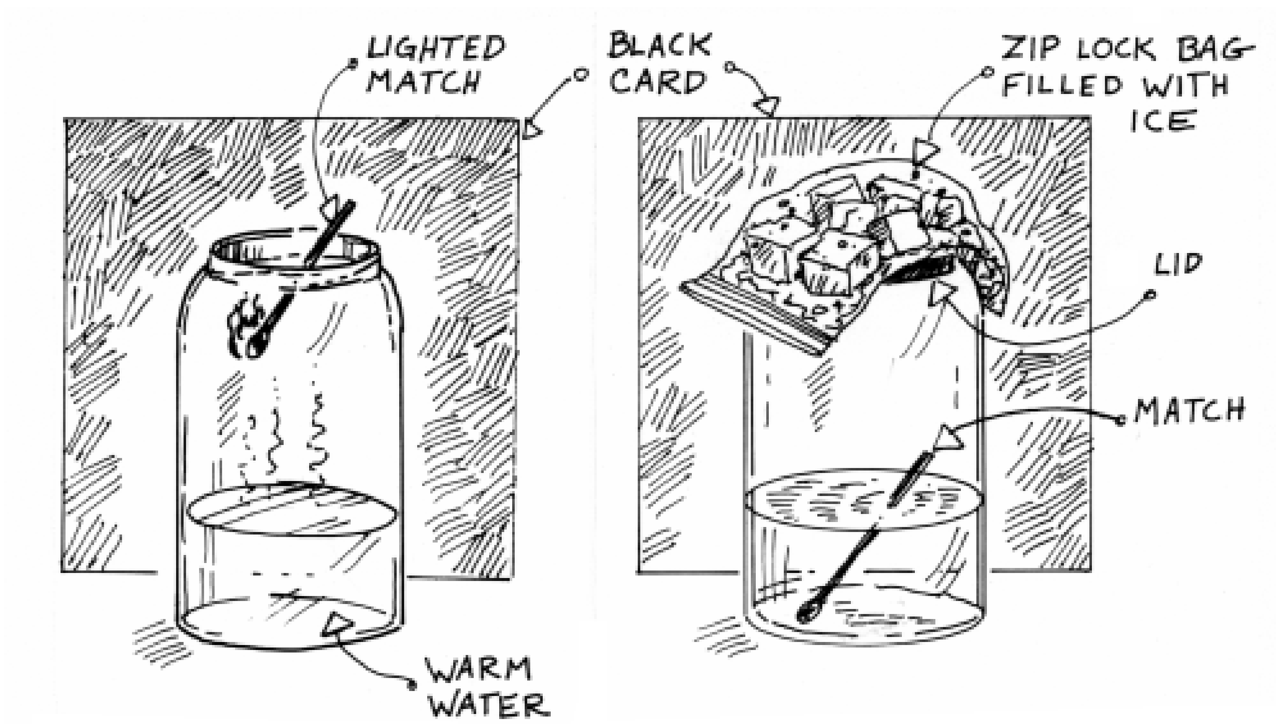
   a. Fill the jar 1/3 full with warm water. (The warmer the water, the better the results.)

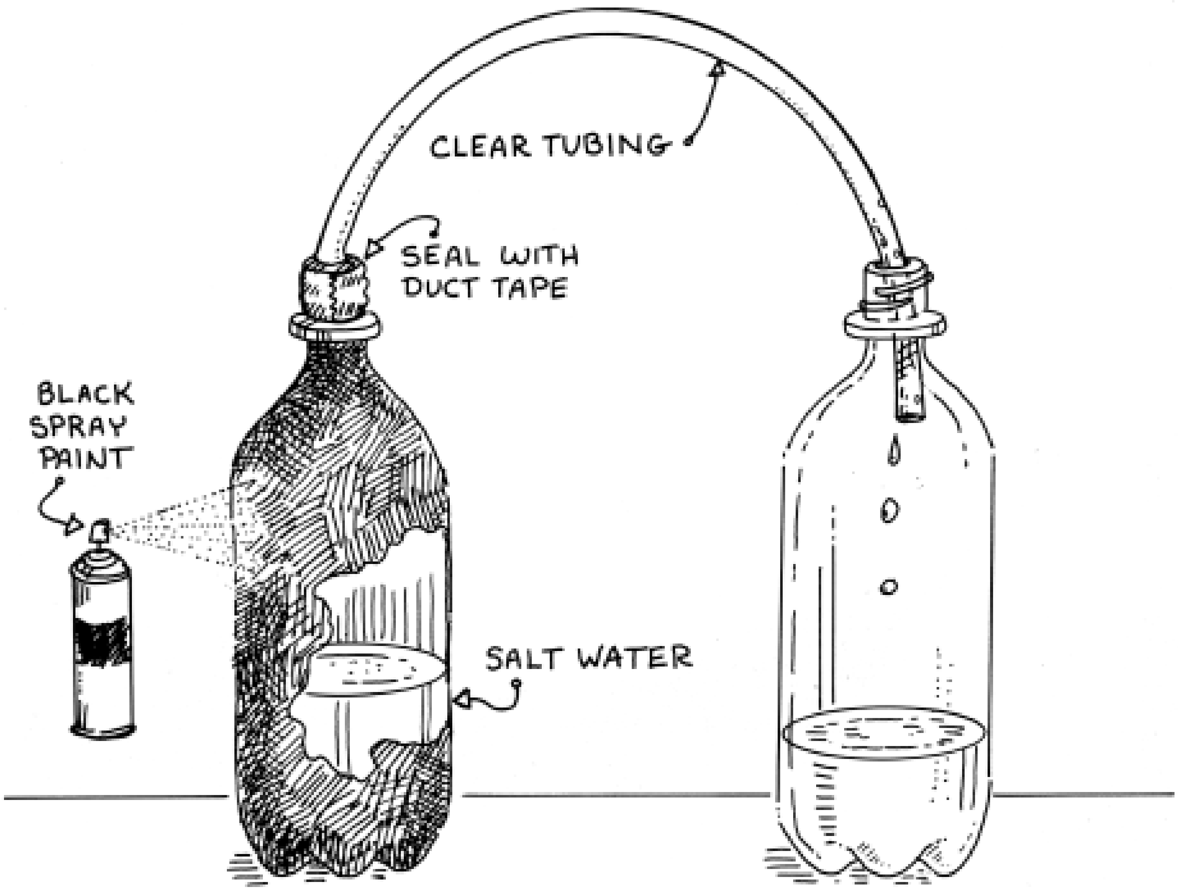
      1) Light the match and hold it over the jar opening.

      2) After a few seconds, drop the match in the jar and cover the top of the jar with the bag of ice.

   b. Observe the inside of the jar against the black paper background.

3. Remind the students that clouds are important because we must have rain to renew our supplies of water.





Follow-Up

A. Ask what processes led to the cloud formation. (evaporation from warm water; condensation on dust particles because of the cooler air temperature from the ice bag) What if it was much colder? (Ice crystals would form and it would be "snow!")

B. Why was smoke from the match important to cloud formation? (Provided particles for vapor to "grab on.")

C. Review the student maps of water sources.

   1. Ask where the surface waters get their water. (rain or groundwater)

   2. Ask what happens to the rain or snow that falls on the ground. (Some replenishes surface or groundwater; some evaporates; some is used by living things.)

IV. Extensions

A. Observe the streams of rainwater runoff on a rainy day and discuss where they will end up.

B. Ask the students to pretend that the area they are living in has a drought.

HARD OR SOFT?

OBJECTIVES

The student will do the following:

1. Discover that water containing excessive dissolved minerals is called hard water.

2. Compare hard and soft water properties.

3. Identify health effects of hard water and soft water.

SUBJECTS:
Science, Language Arts, Health

TIME:
60 minutes

MATERIALS:
2 one-liter plastic bottles with caps
distilled water
Calgon® water softener
Epsom salts
liquid soap
2 quart-size (1-L) clear containers or two 1-liter bottles with the tops cut off
1/2 cup (125 mL) soil
student sheet (included)

BACKGROUND INFORMATION

In nature, water circulates through a system called the water cycle. There are two main sources of fresh water: surface water and groundwater. Surface water flows over the land in lakes, rivers, and streams. Groundwater seeps through the soil or through cracks and cavities in rocks.

Fresh, clean, unpolluted water is something no one should take for granted. Only three hundredths of one percent of the earth's water is drinkable (three out of 10,000 gallons of water on earth).

Minerals that cannot be seen are dissolved in water naturally. Water that is high in some minerals is called hard water. Hard water has economic, as well as health, effects. Laundry washed in hard water may require more detergent and energy to get clean. Links have been drawn to kidney stones in people and high dissolved mineral content in the water they drink.

Water that has a low mineral content reduces the amount of detergent needed, but generally has a higher level of sodium. Sodium in high levels is linked to heart disease, stroke, and high blood pressure. Water with low mineral content is usually corrosive and can leach lead out of solder in plumbing.

Depending on where you live, the water may have more or fewer minerals than water in other parts of the country. The amount of minerals in water makes it "hard" or "soft." "Hard" water gets its name because it is "hard" to make suds in it. The minerals in the water combine with soap to make a gray film instead of suds. It is this film that leaves a ring around a bathtub.

Terms

groundwater: water that infiltrates into the earth and is stored in usable amounts in the soil and rock below the earth's surface; water within the zone of saturation.

hard water: water that contains a large amount of dissolved minerals.

soft water: any water that does not contain large amounts of dissolved minerals but may be high in sodium.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans..

ADVANCE PREPARATION

A. Gather all the materials. Everything you need is available at grocery or drug stores (or maybe even in your home).

B. Fill the two clear containers. Add 1/2 cup (125 mL) soil to one container to make it "muddy" looking. You will be using the two containers to compare clear water to "muddy" water.

C. The activity will compare hard and soft water. In order to provide observable results, we will make our own hard and soft waters.

   1. Begin by filling each of the liter bottles with distilled water, leaving an inch (2.5 cm) space at the top.

   2. In one, dissolve 1/2 cup (125 mL) of Epsom salts. Label this one "Hard Water."

   3. In the other, dissolve 1/2 cup (125 mL) Calgon® or similar brand water softener. Label this one "Soft Water." (This water will have a blue tint, but will become clear in a short time.)

D. Photocopy the student sheet.

PROCEDURE

I. Setting the stage

A. Ask the students to brainstorm different types of water pollution.

B. Show the class the two containers holding clear and "muddy" water.

   1. Ask which one they would drink. (All will probably choose the clear water.)

   2. Ask and encourage students to discuss the possible effects of drinking the dirty water.

C. Ask the students to brainstorm adjectives that might describe water. (clear, cold, muddy, etc.)

   1. Tell the students that water can also be described as "hard" or "soft."

   2. Write the terms "hard water" and "soft water" on the board. Can they imagine what this might mean?

D. Show the class the two bottles labeled "Hard Water" and "Soft Water."

   1. Ask which one they would drink. (Most likely, there will be indifference since both look clear.)

   2. Ask and encourage students to discuss the possible effects of drinking either container of

water.

3. Inform the students that sometimes it is difficult to distinguish whether drinking water is pure or impure.

II. Activity

A. Allow the bottles of water to sit overnight. (This will allow settling to occur. Encourage the students to compare the bottles and their sediments.)

B. Explain that minerals that cannot be seen exist in water naturally. The more dissolved minerals, the harder the water. (Optional: If you live in an area with hard water, you may have examples around your house of how this water can leave mineral deposits. Check your tea kettle for a crust of minerals left by water. You can probably find other examples in you home, too.)

1. Show one of the properties that distinguishes between hard and soft water by adding liquid soap (a hearty squeeze) to each. With the lids on tight, shake each as hard as you can. (NOTE: You might allow two students each to do one bottle.)

2. Observe the differences in the soap suds level. (More suds appear in soft water.)

3. Encourage class discussion on the effects of having hard or soft water in the home. (You need less soap to wash clothes, dishes, bodies, hair, etc., if you have soft water.)

C. Pass out student sheet, "Hard or Soft Water."

1. Discuss the sources and household and health effects of hard water.

2. Discuss the sources and household and health effects of soft water.

III. Follow-Up

A. Have each student repeat the suds demonstration at home.

1. The students should orally report their findings to the class the following day.

2. Make a class chart showing the results.

3. Have the students graph the results.

B. You may assign a student to test the school water supply (drinking fountain or sink).

C. Ask the students to answer the following questions:

1. You have hard water; your friend has soft water. Who will need more bubble bath for a tub full of bubbles? (you)

2. People in your community seem to have a lot of kidney stones. If the Health Department tests the water to check its mineral content, they might be expecting to find the water is very (<u>hard</u>/soft)?

3. A community has very soft water, which corrodes peoples' plumbing. What metal can the soft

water cause to be in the water from the pipes? (lead)

4. The water at your grandparents' house tastes very metallic. It is hard or soft water? (hard)

5. When you go to the beach, the water lathers your shampoo so much, you have a hard time rinsing it out of your hair. Is it hard or soft water? (soft)

IV. Extensions

A. Have a representative from your water utility answer questions about the local water supply. (Be sure to talk to the representative ahead of time about discussing only dissolved minerals.)

B. Invite a representative from the local health department to present a classroom presentation on the health effects associated with hard and soft waters.

C. Visit a water treatment plant.

RESOURCES

"About Safe Drinking Water," Channing L. Bete Co., New York, 1990.

Seehafer, Roger W, Health: Choosing Wellness (Teacher's Edition, Grades 9 - 12), Prentice-Hall, Englewood Cliffs, New Jersey, 1989.

HARD OR SOFT WATER

Type	Mineral Content	Problems to Household	Problems to Human Health
Hard water	High concentrations of minerals such as copper, limestone, iron, magnesium, and calcium. Low sodium content.	Metallic taste of water. Staining of porcelain and laundry. Need more detergents to clean and lather.	Kidney stones may be related.
Soft water	Low concentrations of minerals such as copper, limestone, iron, magnesium, and calcium. High sodium content.	Lathers soap easily. Common cause of plumbing corrosion.	Cardiovascular disease may be related. Lead in water increases due to plumbing corrosion.

GET THE SALT OUT!

SUBJECTS:
Science, Geography

TIME:
2 45-minute periods

MATERIALS:
world map
5 clear drinking straws
1/4 lb (100 g) clay
20 to 30 steel BB's
tap water
permanent ink pen
metric rulers
3 samples of liquids
3 clear glass quart jars
student sheet (included)
table-tennis ball
golf ball
clear plastic pitcher
mixing spoon
duct tape
2 glasses of water
teacher sheet (included)
two 2-liter bottles
black paint
12 inches (30 cm) of clear plastic tubing (as for aquarium)
aluminum foil
salt
small (bathroom) paper cups (1 per student)

OBJECTIVES

The student will do the following:

1. Demonstrate that salt water can be changed to fresh water by evaporation (desalination).
2. Make and use a hydrometer to measure the density (saltiness) of water.
3. Research places in the world where desalinated water is the main source of drinking water.

BACKGROUND INFORMATION

Salt water makes up 97 percent of all the water on the earth. Though abundant, salt water is not potable, or fit to drink.

Fresh water can be obtained from salt water by a process called desalination. There are several ways to desalinate salt water: evaporation, reverse osmosis, membrane electrolysis, and freezing. The least expensive of these methods is usually evaporation.

Desalination is seen as a solution to fresh water shortages by some people, but the energy requirements of these procedures cause desalinated water to be very expensive. Desalinated water costs six times as much per unit as fresh water.

As of 1985 about 600 desalination plants around the world produced approximately 250 million gallons (947 million L) of fresh water per day. That is only 0.4 percent of the U.S.'s daily water use and 0.006 percent of the world's daily water use.

A hydrometer is a device used to measure the density of liquids such as salt water. The higher a hydrometer floats in a liquid, the more dense or salty the liquid is.

Terms

density: a measure of mass per unit of volume of a substance.

desalination: the purification of salt or brackish water by removing the dissolved salts.

evaporation: the process by which liquid water becomes vapor in the atmosphere.

hydrometer: a device that measures the density of water.

ADVANCE PREPARATION

A. Copy student sheet.

B. Thoroughly clean the two 2-L bottles. Paint one of them black.

C Obtain the clear tubing from any store selling aquarium supplies. Wash it out well.

D. Mix the following solutions in clear jars and label: 1) 2 tablespoons (30 mL) salt in 3/4 quart (750 mL) water, A; 2) 4 tablespoons (60 mL) salt in 3/4 quart (750 mL) water, B; and 3) 6 tablespoons (90 mL) salt in 3/4 quart (750 mL) water, C.

E. Prepare 2 glasses of water, one labeled as tap water with a price of 1 cent (A) and one labeled as desalinated water with a price of 6 cents (B).

F. Fill clear plastic pitcher with water.

PROCEDURE

I. Setting the stage

A. Display a map of the world and the two labeled glasses of water at the front of the room.

1. Discuss with the class the availability of water. Ask the following questions:

    a. Do you ever run out of water at your house? (no; except for unusual, and typically short-term, situations)

    b. Can you name a place on earth where people might run out of water to drink? (the desert)

    c. Can you drink sea water? Why not? (No, it's too salty.)

    d. Can you change sea water to make it drinkable? (Accept all answers. Then explain that sea water can be made drinkable.)

2. Point out Saudi Arabia on the map and explain to the class that in this region of the world people must get their water from the sea.

a. Hold up the two glasses of water and ask, "Who would like to buy a glass of water? Glass A costs 1 cent and glass B costs 6 cents."

b. Explain that water in Saudi Arabia costs six times as much as water in the U. S.

B. Write the word desalination and its definition on the board.

1. Explain that the Saudi water is desalinated sea water and that is why it costs six times as much as ours.

2. Tell the students that you will demonstrate how to desalinate water by the process of evaporation. See the diagram on the teacher sheet "desalination."

3. Add 2 tablespoons (30 mL) salt to the fresh water in the clear 2-liter plastic bottle and mix.

4. Pour the salt water into the black 2-liter bottle.

5. Attach the clear tubing to the black bottle and the clear bottle. Seal with duct tape.

6. Set both bottles in a sunny window with the black bottle 3 to 4 inches higher than the clear bottle.

II. Activity

A. Hold up a golf ball and a table-tennis ball. Ask the following questions:

1. Which ball is denser?

2. Which ball will float?

B. Write "density" and its definition on the board. Explain that the golf ball is denser than the table-tennis ball because the golf ball is solid, while the table-tennis ball is hollow.

C. Divide the students into teams of 5 each.

1. Pass out the student sheets on the hydrometer.

2. Write "hydrometer" and its definition on the board.

3. Explain that each team will make a hydrometer to test the density of three different liquids.

4. Have one student from each team pick up all the materials needed to make the hydrometer (listed on the student sheet "Hydrometer").

5. Students will follow the directions on the student sheet through Step 5 to complete the hydrometer. If hydrometers do not float, it is probably because the students have used too much clay. They should remove some of the clay and try again. (NOTE: For third grade, you may lead the groups step by step through the process.)

D. Groups will come up one at a time to the testing table to test the density of solutions A, B, and C.

1. Each team will record the results of their test.

2. Teams will answer the questions under observations and conclusions. (NOTE: This section may be done as a teacher-led discussion. The results should show that A is the least dense

salt water, B has medium density, and C is the most dense. Tap water should prove to be even less dense than A.)

III. Follow-Up

After an observable amount of water has collected in the clear bottle from the desalination demonstration, pour water into cups from the black and clear 2-liter bottles. Have students taste each by giving each student a small paper cup and dispensing to each a very small taste from each of the two bottles. (NOTE: Remind the students never to taste anything used in an experiment unless it is a safe substance and they are specifically directed to taste it.) Was there a difference? (Water from the black bottle is salty tasting and water from the clear container is not salty.)

IV. Extensions

A. Allow the desalination demonstration to continue until enough water has collected in the clear bottle to test the density of it. Compare its density to the density of the water in the black bottle.

B. Have the students choose several countries they believe would use desalinated water and research whether those nations have desalination plants to provide drinking water.

C. Freeze salt water to separate the salt and water.

D. Try to float an egg in salt water and in tap water as another way to show their comparative densities.

RESOURCES

Handwerker, Mark, et al., Earth Science, Harcourt Brace Javanovich, Inc., Orlando, Florida, 1989.

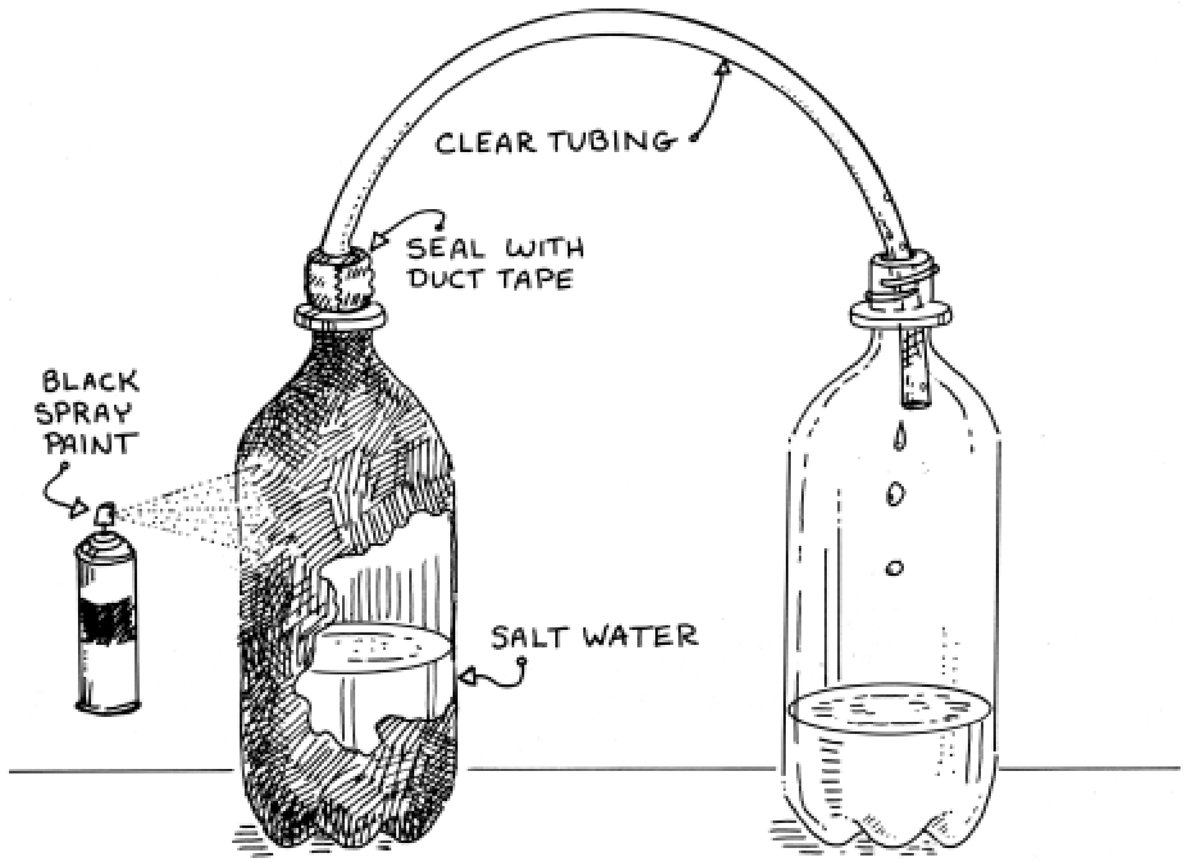
Hurd, Dean, et al, General Science: A Voyage of Adventure, Prentice-Hall, Englewood Cliffs, New Jersey, 1989. (Laboratory activity adapted from p. 518.)

Miller, Tyler G., Environmental Science: An Introduction, Wadsworth Publishing Co., Belmont, California, 1986.

Miller, Tyler G., Living in the Environment: Concepts, Problems, and Alternatives, Wadsworth Publishing Co., Belmont, California, 1975.

Teacher Sheet

DESALINATION



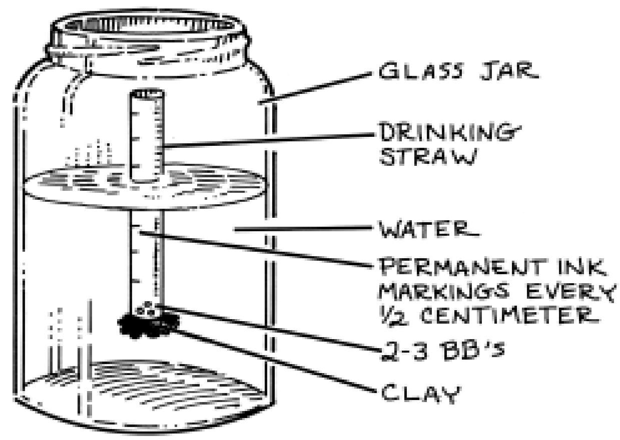
1. Spray paint one of the 2-liter bottles black before class.
2. In a clear pitcher mix 1/2 cup (125 mL) salt in 1 quart (1 L) of water.
3. Pour into the black 2-liter bottle.
4. Attach the clear tubing to both 2-liter bottles and secure with duct tape.
5. Set both bottles in a sunny window. Place the black bottle higher than the clear bottle.
6. Experiment with putting aluminum foil around the black bottle to heat it up more.

Student Sheet

HYDROMETER

Name____________________ Date____________________

Materials (per team):



1 clear plastic drinking straw
small piece of clay
2 to 3 steel BB's
mayonnaise jar (or 2 liter bottle with the top cut off)
fresh water
pencil of permanent ink pen
metric ruler

1. Cut straw in half and fill one end with clay.
2. Mark off 1/2 centimeters along the straw with a permanent ink pen.
3. Fill the jar 3/4 full of tap water.
4. Put 2 or 3 BB's in the open end of the straw. Let them roll down to the clay.
5. Put the straw into the water, clay end down. It should float. Add BBs until your hydrometer floats very low in the water. Only 2 or three lines should be above the water.
6. Record the exact level at which your hydrometer floats. When testing, the higher your hydrometer floats, the more dense or salty the liquid is. Pour the tap water out of the jar.
7. Your teacher will provide you with three samples to test. They are labeled A, B, and C.
8. Gently put your hydrometer into each liquid sample (one at a time) and record the level at which it floats each time.

Observations and conclusions:

1. Including your fresh water sample, list the samples in order of least dense to most dense.

2. In a liquid less dense than water, how would your hydrometer float?

3. In a liquid more dense, how would your hydrometer float?

4. Compare a floating object in salt water and fresh water.

THE MAIN DRAIN

OBJECTIVES

The student will do the following:

1. Identify the septic tank as an alternative method of wastewater treatment.
2. Observe how a septic tank works.
3. Demonstrate how a septic tank works.

SUBJECTS:
Science, Language Arts, Math

TIME:
45-60 minutes

MATERIALS:
one plastic or cardboard box or lid
(6-8 inches [15-20 cm] deep)
one garbage bag (if cardboard box is used)
potting soil or topsoil
three empty paper milk cartons - one each:
half gallon (2 L), quart (L) and pint (0.5 L) cartons
plastic straws
large needle
ice pick or awl
scissors
marking pen
masking tape
modeling or florist clay
ruler with English/Metric measurement
teacher sheet (included)

BACKGROUND INFORMATION

People who live in small towns and rural areas are often not connected to a sewage treatment system; therefore, they must depend on an alternative method of disposing of wastewater. Septic tank systems provide a safe and effective means for waste disposal if they are properly sited, installed, and maintained.

A septic tank is a large concrete or fiberglass tank that is buried underground. Drain pipes carry sewage and wastewater from buildings into the tank. By bacterial action, much of the sewage is reduced to liquid, which flows out of the tank through the drainpipe to the drainfield. The solids (sludge) settle to the bottom of the tank. This solid material must be periodically pumped out of the tank and disposed of at a waste treatment facility or an approved disposal site.

The drainfield allows wastewater to seep into the soil. The soil filters bacteria and nutrients from the wastewater. The water is further purified by the microorganisms that live in the soil.

Many states regulate the siting of septic systems and the distance between a septic tank and groundwater resource. They also may specify the types of soil where the system can be placed. Some states and local governments have regulations requiring inspection and maintenance schedules for septic systems.

Lagoons, wetlands, and sand filters are other alternative methods that rural areas may use to treat wastewater. However, if these methods are improperly sited, poorly constructed, and/or poorly maintained, they become a serious threat to groundwater quality and public health.

<u>Terms</u>

drainfield: the part of a septic system where the wastewater is released into the soil for absorption and filtration.

lagoon: an animal waste treatment method which uses a deep pond to treat manure and other runoff from a livestock operation. Lagoons can be aerobic or anaerobic. Both use bacteria to break down materials.

sand filter: a filter system used to treat wastewater where sand and gravel are mounted on top of the natural soil.

septic tank or septic system: a domestic wastewater treatment system into which wastes are piped directly from the home; bacteria decompose the waste, sludge settles to the bottom of the tank, and the treated effluent flows out into the ground through drainage pipes..

siting: the process of selecting the correct location for a septic tank.

sludge: solid matter that settles to the bottom of septic tanks or wastewater treatment plant sedimentation; must be disposed of by bacterial digestion or other methods or pumped out for land disposal or incineration.

wetland: an area that, at least periodically, has waterlogged soils or is covered with a relatively shallow layer of water.

ADVANCE PREPARATION

A. Gather materials for septic tank model. Prepare the cartons and straws as follows:

1. Cut the top off the 1/2 gallon (2 L) milk carton. It should be 6 inches (15 cm) deep. Label this carton "house."
2. Cut the quart (L) size to 3 inches (7.5 cm) deep and label it "septic tank."
3. Cut the pint (1/2 L) size to 1/ 2 inch (1.3 cm) deep. Label it "drainfield tank."
4. Cut the holes in the boxes for inserting the straws; use an ice pick or awl.
5. Make holes in the straws using a large needle. Make numerous holes, enlarging them by working the needle back and forth.

B. If you do not have a plastic blanket or sweater storage box to use, cut a large cardboard box down (a copy paper box works fine); line it with plastic by inserting it in a garbage bag and tying off the bag with the box inside.

C. Have copies of the model diagram (teacher sheet) for the students to refer to during the construction.

D. Invite a water quality representative to come to speak to the class.

PROCEDURE

I. Setting the stage

A. Put the following questions on the board or use sentence strips and place them on a pocket chart. (These assume that you are located in an area not served by a wastewater treatment plant.)

1. What happens to the wastewater and sewage when it leaves your house?

2. Where does the sewage/waste water go when it leaves the school?

B. Explain how a septic tank system works. Paraphrase the background information.

C. Compare/contrast a septic tank system and a wastewater treatment plant. List advantages and disadvantages of both.

II. Activities

A. The students will construct a model of a septic tank system with a drainfield.

B. Show the class the diagram of the model of a septic tank system.

1. Instruct the students to prepare the large box for the septic tank system model. The box should be filled 1/2 full of soil.

2. Cut the tops from the milk cartons (if this has not previously been done).

C. Assemble the septic tank system.

1. Instruct the students to connect the three boxes, from the largest to the smallest, with the straws (refer to diagram). Use ice pick or awl to make holes in boxes (if not already done). Fit the straws into the holes, connecting the boxes with the straws. Use small pieces of masking tape to seal leaks by making "collars" of tape around the connection between box and straw.

2. Instruct them to assemble the drainfield. Connect straws following the diagram of model. (To make the connections between straws, you will have to make large holes in the straw crosspiece; use the ice pick or awl.) Use a large needle to punch drain holes through the straws. Plug the ends of the drains (straws) with modeling or florist clay. Use masking tape to seal any leaks.

3. Test for leaks by putting the model in a sink and filling "house" with water. Water should only come out of the holes in the drain (straws).

D. As the assembly progresses, discuss with the students what each part of the model represents.

E. Test the septic tank system.

1. Put the model in the box with the porous soil.

2. Pour water in the "house" slowly. Observe what happens. Ask the students to explain what happens. (The water should go to the drainfield and trickle into the soil.)

III. Follow-Up

A. Have the students ask their parents what type of wastewater disposal they have. Construct a bar or circle graph to represent the type of wastewater disposal the students have in their home: (1) wastewater treatment plant, (2) lagoon, (3) septic tank, (4) wetland, (5) sand filter. What percentage does each group represent?

B. Did any parents tell what type of maintenance schedule has to be followed to keep the system working properly?

C. Brainstorm with the group the answers to these questions:

1. What happens if the system does not function properly? (Malfunctioning septic systems will have a smell or have noticeable wetness on the ground above them. Such systems represent a threat to public health and to nearby groundwater supplies.)

2. What do you think will happen to the water supply in the area if the waste disposal system does not work properly or is not maintained adequately?

IV. Extensions

A. Invite a water quality representative to come and speak to the class about wastewater treatment in their area.

1. Ask what type of waste disposal systems are represented in the area.

2. What kind of local or state regulations or restrictions are mandated for maintenance, siting, and construction of wastewater facilities in the area?

B. Write to a local or state water quality agency and ask them to send information about septic tanks.

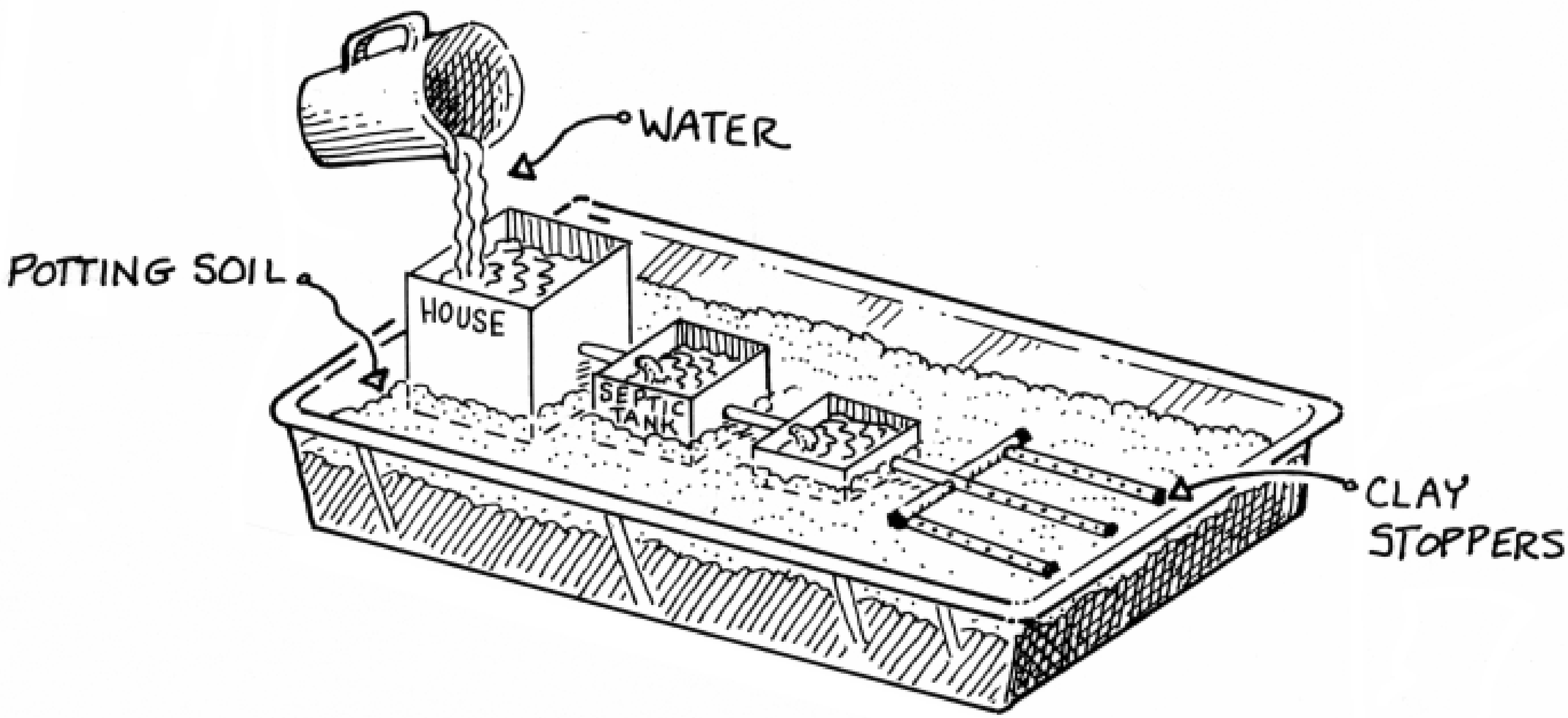
RESOURCES

Branley, Franklyn M., Water for the World, Thomas Y. Crowell Junior Books, New York, 1982, p. 77.

Environmental Resource Guide: Nonpoint Source Pollution Prevention (Grades 6-8), Air and Waste Management Association, Pittsburgh, Pennsylvania, 1992.

Jorgensen, Eric P., ed, The Poisoned Well: New Strategies for Groundwater Protection, Island Press, Washington, DC, 1989.

SEPTIC TANK MODEL



THE WASTEWATER STORY

OBJECTIVES

The student will do the following:

1. Identify what wastewater is and where it comes from.
2. Explain why wastewater must be treated before it is returned to the water supply.
3. Know the steps in the wastewater treatment process.
4. Utilize wastewater treatment vocabulary in a flow chart.

SUBJECTS:
Science, Art, Math

TIME:
45 minutes

MATERIALS:
overhead projector
acetate sheets
drawing paper
teacher sheets (included)
student sheets (included)

BACKGROUND INFORMATION

Each person uses an average of 150 gallons (570 L) of water a day. All of the clean water that comes into your house by one set of pipes, leaves your house by another set of pipes; clean water becomes wastewater. Wastewater comes from houses, schools, businesses, industry, and storm runoff.

In cities, wastewater goes into sewers and then to wastewater treatment plants. In the country, wastewater goes into large underground tanks called septic tanks.

Treatment of wastewater at a treatment plant includes the following steps; primary treatment, secondary treatment, and advanced treatment. The primary treatment of wastewater uses bar screens to filter out objects like sticks, rags, and rocks, and sedimentation tanks to settle out suspended solids. Suspended solids are pumped from the bottom into another settling tank. Secondary treatment uses a biological process where bacteria break down the wastes. The wastewater is run through aeration tanks where air is added and the waste is stirred to aid the growth of bacteria. The bacteria attach to suspended solids; these settle out in the secondary sedimentation tank. The advanced treatment process includes filtering through sand and gravel, disinfection using chlorine, ultraviolet light, or ozone to kill dangerous or pathogenic (disease-causing) bacteria.

The cleaned wastewater can be used for irrigation or released back into a lake or river. For discharge and disposal, wastewater must meet standards set by federal and state governments. Wastewater solids, meeting additional criteria for beneficial use, are called biosolids. They can be used as a nutrient-rich fertilizer. The average person produces approximately 200 pounds of biosolids per year.

Terms

advanced treatment: the third or last step in cleaning wastewater using sand and gravel filters; chlorine may be added after this.

bacteria: small living organisms that consume the organic parts of sewage.

biosolids: solid materials of organic origin resulting from wastewater treatment formerly referred to as "sludge"; meet federal standards for beneficial use, such as land application.

effluent: waste material (such as water from sewage treatment or manufacturing plants) discharged into the environment.

primary treatment: the first process in wastewater treatment which removes settled or floating solids.

reclaimed water: effluent usable for irrigation or ready for release into lakes and rivers.

secondary treatment: the wastewater process where bacteria are used to digest organic matter in the wastewater.

sewer system: an underground system of pipes used to carry off sewage and surface water runoff.

suspended solids: undissolved waste particles in wastewater.

wastewater: water that has been used for domestic or industrial purposes.

wastewater treatment facility: a facility for cleaning and treating wastewater before discharging into a water body.

water conservation: practices which reduce water use.

ADVANCE PREPARATION

A. Prepare a large poster or overhead transparencies from teacher sheets "Down the Drain," "Wastewater Treatment Process Answer Key," "Flow Chart Symbols," and "Flow Chart Answers."

B. Make copies of student sheets "Wastewater Treatment Process," "Flow Chart Directions," and "Flow Chart."

PROCEDURE

I. Setting the stage

A. Ask the class the following questions:

1. Who brushed their teeth today? Whose parents washed their clothes this week?

2. Count hands for each question and list numbers on the board.

B. Display the poster or overhead of the teacher sheet "Down the Drain" and ask these questions:

1. Where does this pipe (at the bottom of the diagram) go?

2. Where does the water go when it goes down the pipe?

II. Activities

A. Pass out a sheet of drawing paper to each student.

1. Have the students draw a picture of where they believe the pipe and water go.

2. Have the students describe their wastewater route in paragraph form. (NOTE: You may need to review proper paragraph form.)

B. Pass out the student sheet "Wastewater Treatment Process." Lead the class through the steps as explained on the teacher sheet "Wastewater Treatment Process Answer Key." (Use the transparency if you have made one.)

1. Write and explain vocabulary words on board.

2. Have the students label each step as you explain it.

C. Have the students complete a flow chart showing the wastewater treatment process.

D. Display the poster or transparency of teacher sheet "Flow Chart Symbols."

1. Explain or review what a flow chart is (a chart showing how to do something step by step).

2. Read over the explanation of each of the flow chart symbols.

3. Pass out the student sheets "Flow Chart Directions" and "Flow Chart." (Answers appear on the teacher sheet "Flow Chart Answers.")

4. Explain that the students will make a flow chart showing the steps in the wastewater treatment process using the student sheets to help them.

III. Follow-Up

Take the class to visit a wastewater treatment plant. As you tour the facility, remind the students of the flow chart and diagram.

IV. Extension

Simulate a flow chart with the students.

A. Assign process names to students. Give each a process card describing what happens at their station.

B. Tape paper scraps on the wastewater students.

C. As the wastewater students go through the cleaning process, each cleaning process student will describe his/her cleaning process and remove one paper scrap.

D. Continue until all wastewater students are clean water. (NOTE: You can time wastewater students 5 seconds apart to begin with and then shorten the time to show wastewater overload. This can lead to a discussion on water conservation.)

RESOURCES

Bernstein, Leonard, et al., Concepts and Challenges in Earth Science, Globe Book Co., Englewood Cliffs, New Jersey, 1991.

Burch, Sandra K., “Be Water Wise”, Virginia Water Resource Center, Blacksburg, Virginia, May 1992.

Cobb, Vicki, The Trip of a Drip, Little, Brown and Company, Boston, Massachusetts, 1986.

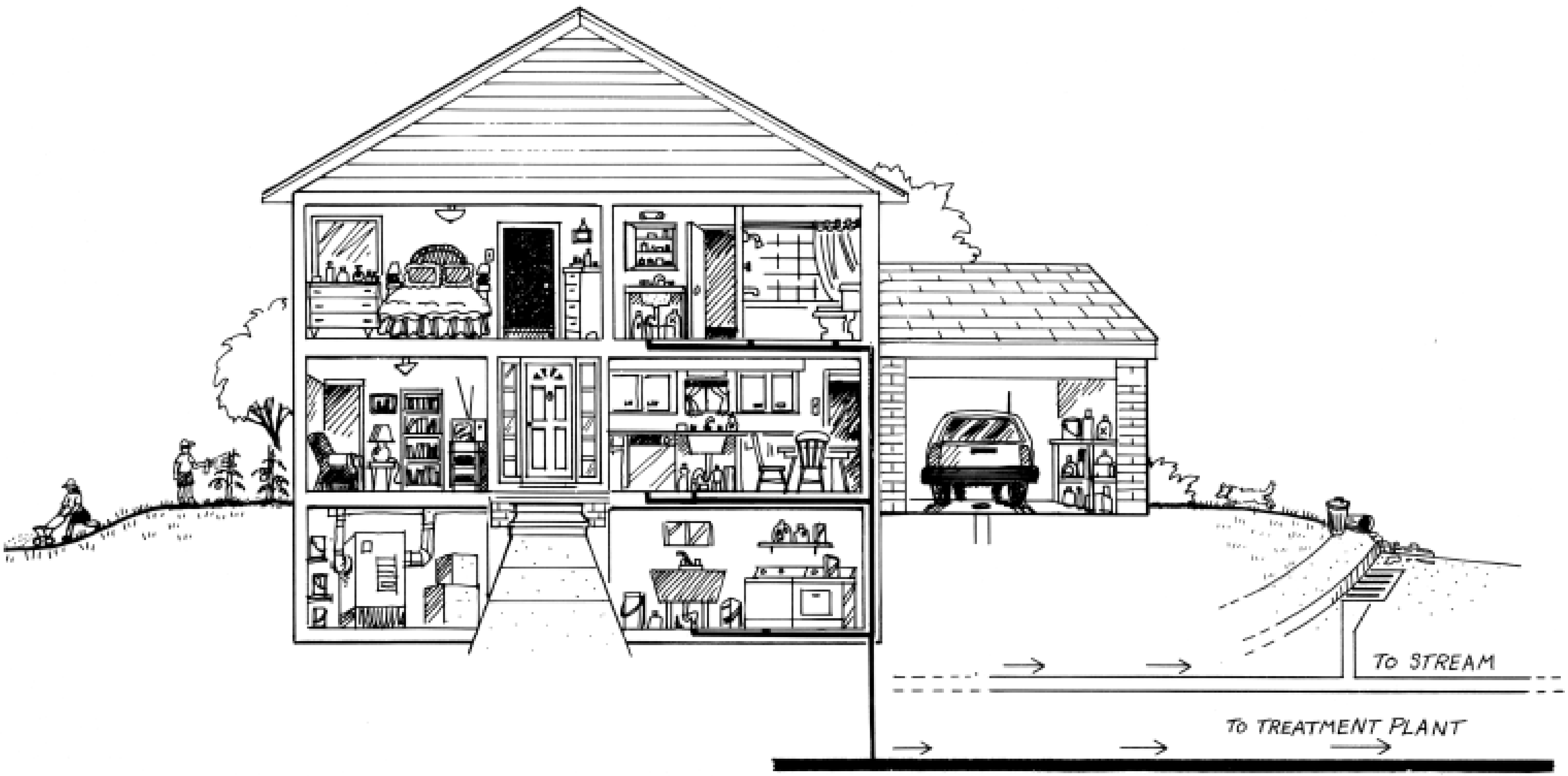
Duckworth, Carolyn, “Dropping in on Water,” Ranger Rick, National Wildlife Federation, Vienna, Virginia, August 1992. p. 30-31.

“Let’s Learn About Wastewater Treatment,” Channing L. Bete Co., Inc., South Deerfield, Massachusetts, 1990.

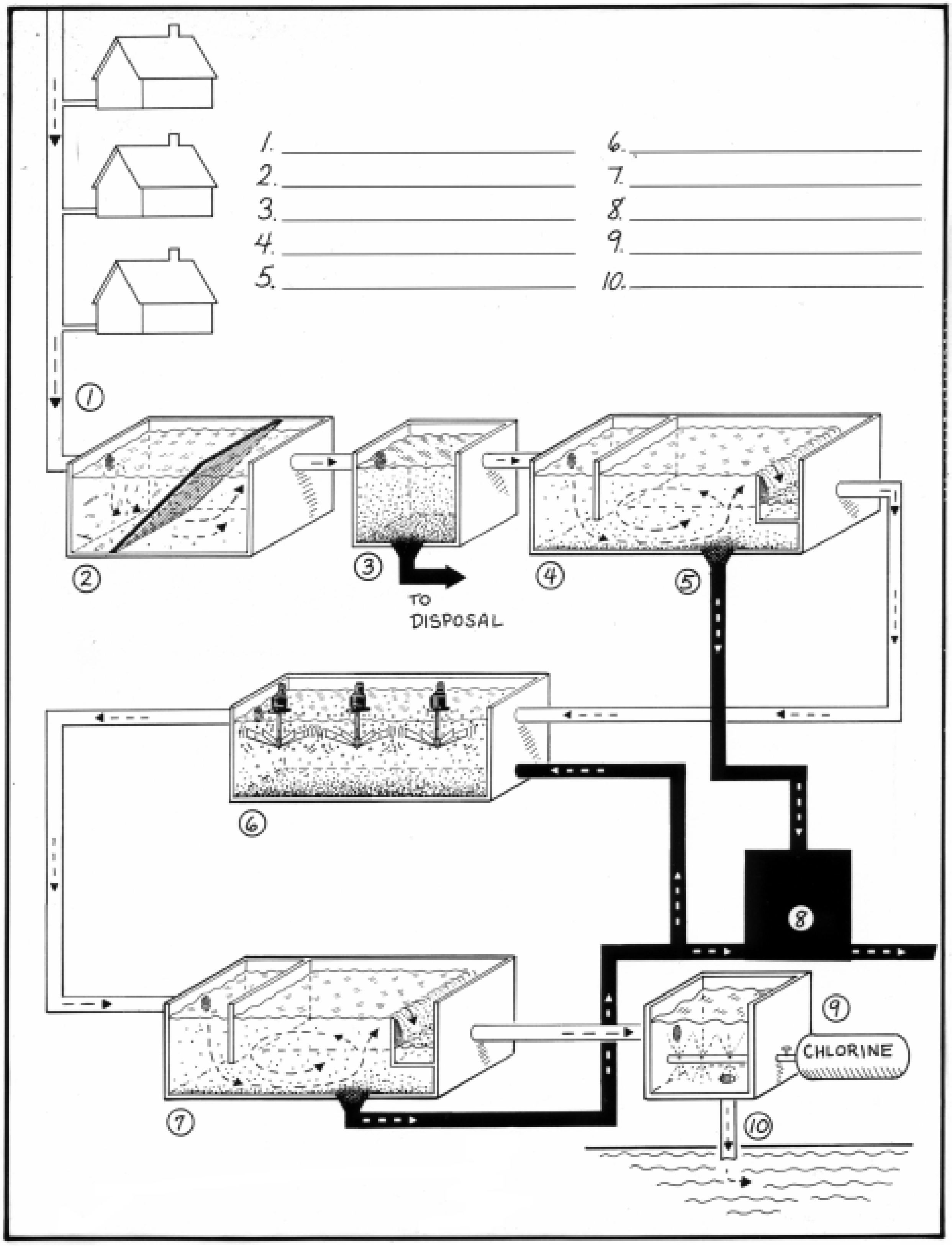
Miller, Tyler G., Environmental Science: An Introduction, Wadsworth Publishing Co., Belmont, California, 1986.

Teacher Sheet

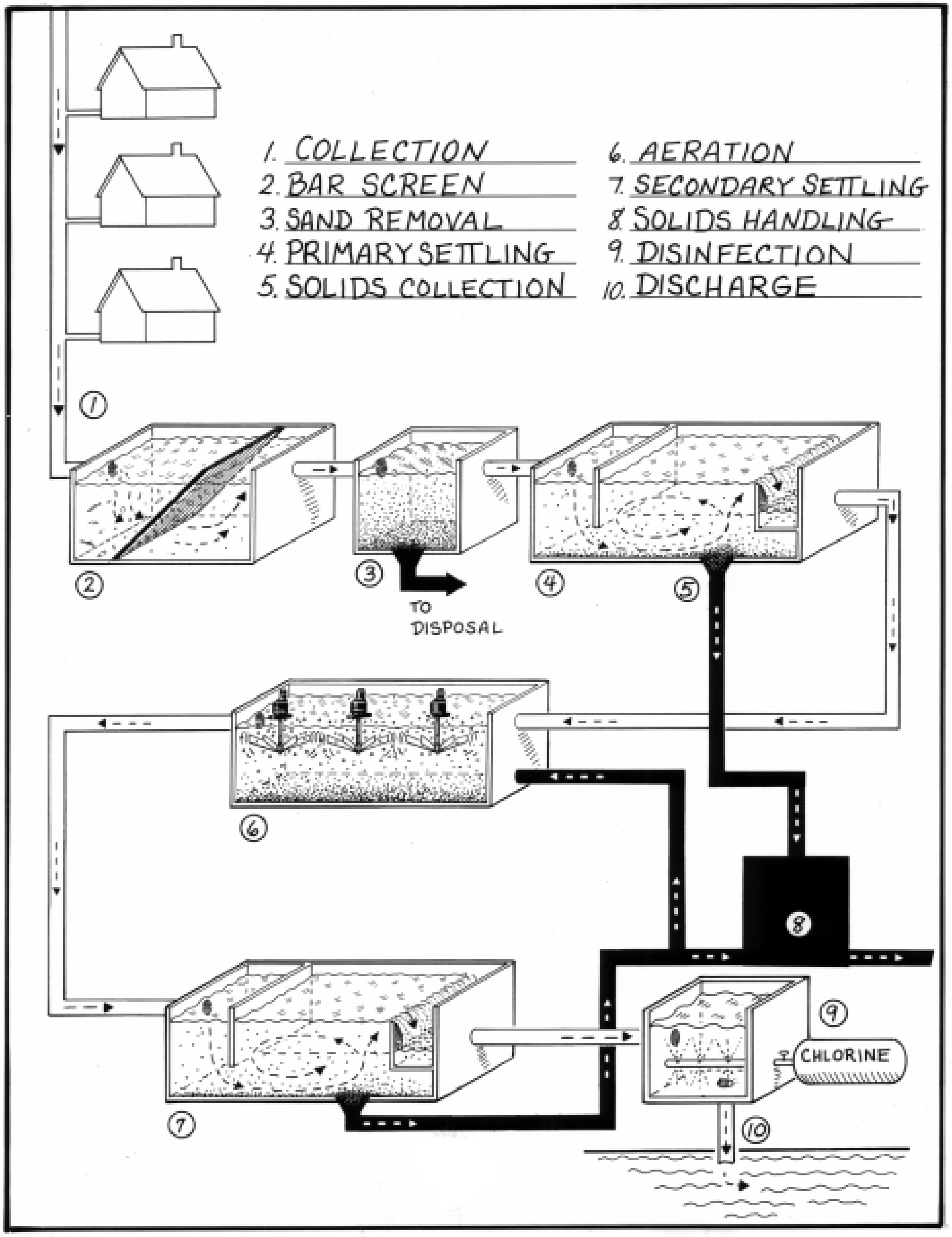
DOWN THE DRAIN



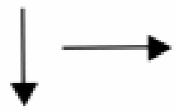
WASTEWATER TREATMENT PROCESS



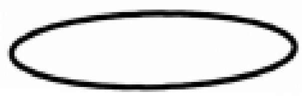
WASTEWATER TREATMENT PROCESS ANSWER KEY



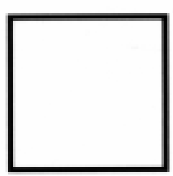
FLOW CHART SYMBOLS



Arrows — Arrows show the direction of the flow of wastewater from process to process.



Start/Stop — An oval is used to show where the treatment process starts and stops.



Square — A square is used to show when chemicals are added to or materials are removed from the wastewater.

Rectangle — A rectangle is used to show when a treatment process is taking place.

Diamond — A diamond is used to show when parts of the wastewater flow go in two different directions.

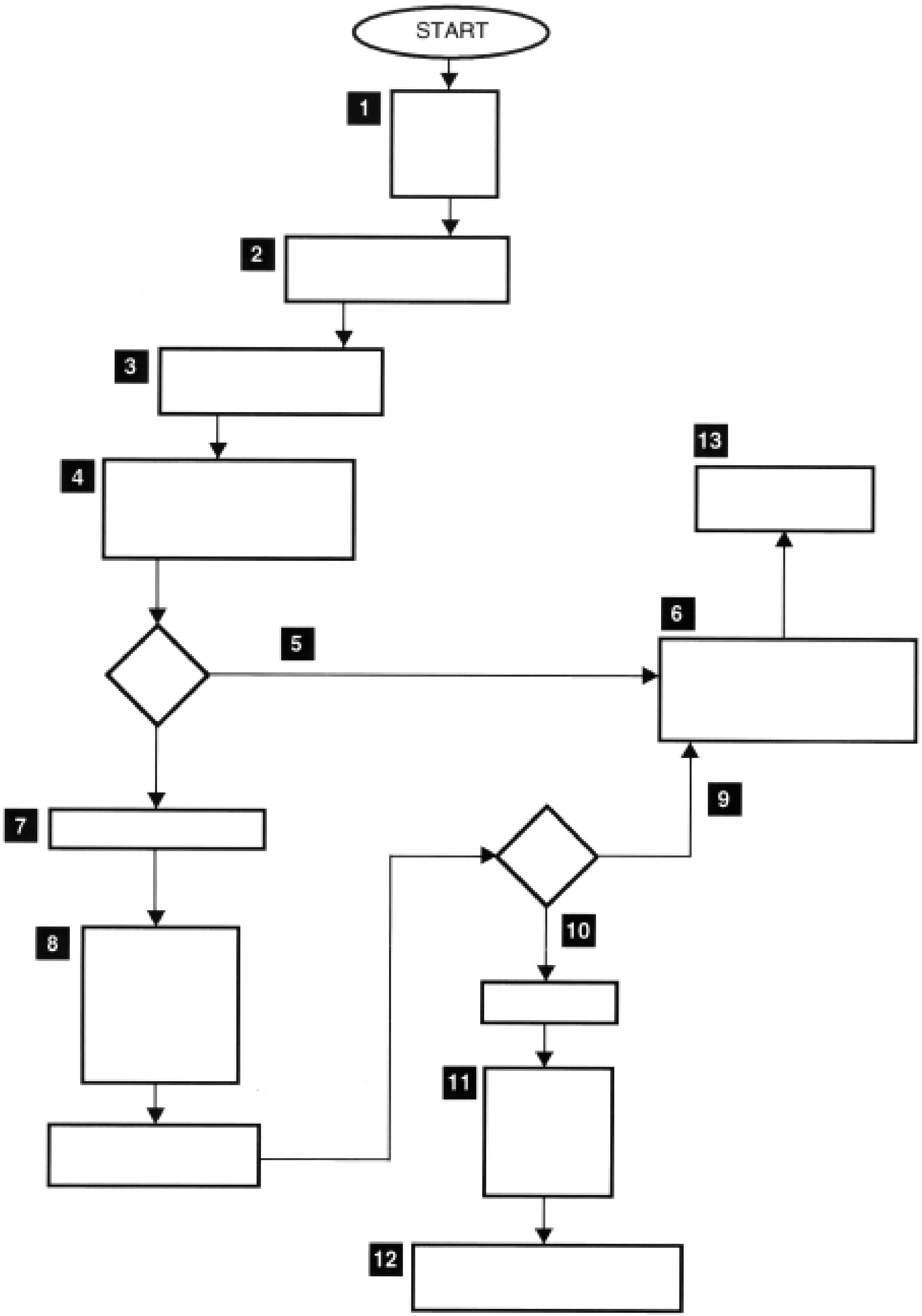
FLOW CHART DIRECTIONS

Name______________________ Date_______________________

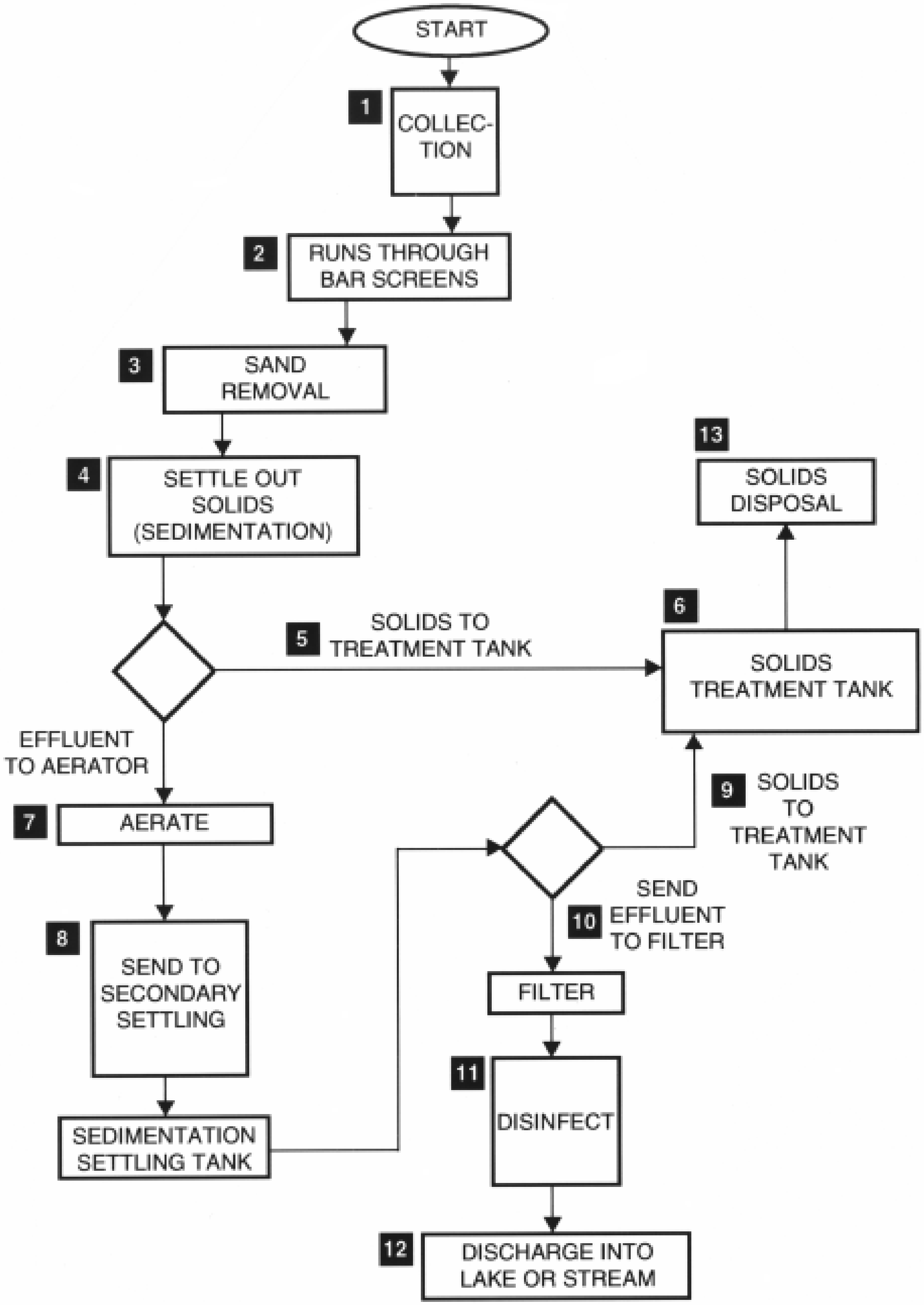
Steps to clean water

1. Intake wastewater (collection)
2. Run through bar screens
3. Remove sand
4. Settle out solids (sedimentation)
5. Send solids to wastewater solids treatment tank
6. Treat solids for disposal
7. Add bacteria to effluent and aerate
8. Send to secondary settling tank (sedimentation)
9. Send solids to wastewater solids treatment tank
10. Send through filtration
11. Disinfect using chlorine, ultraviolet light or ozone
12. Discharge into lake or stream
13. Dispose of solids

FLOW CHART



FLOW CHART ANSWERS



WETLAND IN A BOTTLE

OBJECTIVES

The student will do the following:

1. Differentiate between constructed wetlands and natural wetlands.

2. State that constructed wetlands can be used to treat domestic, agricultural, industrial, and mining wastewater.

3. Observe how plants in wetlands remove wastes from water.

4. State that plants have limited abilities to remove wastes.

SUBJECTS:
Science, Art, Language Arts

TIME:
90-120 minutes

MATERIALS:
teacher sheet (included)
student sheets (included)
8 celery stalks
food coloring
water
paring knife
2 glass jars or beakers
butcher paper or poster board (1 piece per group)
crayons
scissors
glue sticks
gallon (4 L) jar with lid
gravel
sand
soil
sphagnum moss
humus
plants (see teacher sheet)
small animals (see teacher sheet)

BACKGROUND INFORMATION

Natural wetlands are areas like marshes, swamps, bogs, sloughs, and floodplains that are covered with water at least part of the year. Constructed wetlands are similar to natural wetlands, but constructed wetlands are built to treat wastewater from domestic, agricultural, industrial, and mining processes. The water flow in a constructed wetland is spread evenly over the wetland area while the water flow in a natural wetland is confined to small channels.

As a means of treating wastewater, constructed wetlands are much less expensive to build (50 to 90%) than conventional treatment systems. The initial building costs of constructed wetlands are less than the costs of one year of conventional chemical treatment and, once built, the maintenance costs are little to none.

In a constructed wetland, wastewater flows through a septic tank or other primary treatment and into the cell or compartment of the wetland. The bottom and sides of the cell are lined with a waterproof liner to prevent leaks and keep the water level even. Plants such as cattails and bulrushes absorb trace metals. Suspended solids and other trace metals settle to the bottom of the wetland as sediment. As is the case in a wastewater treatment plant, bacteria do most of the work of removing pollutants. Though wetlands plants remove some pollutants, their chief benefit is to provide an enhanced environment for bacterial growth.

Another benefit of constructed wetlands is the creation of wildlife habitat. Constructed wetlands also become areas for educational opportunities.

Terms

constructed wetlands: wetlands that are designed and built similar to natural wetlands; some are used to treat wastewater. Constructed wetlands for wastewater treatment consist of one or more shallow depressions or cells built into the ground with level bottoms so the flow of water can be controlled within the cells and from cell to cell Roots and stems of the wetland plants form a dense mat where biological and physical processes occur to treat the wastewater. Constructed wetlands are being used to treat domestic, agricultural, industrial, and mining wastewaters.

natural wetlands: swamps, marshes, bogs, and low pieces of land soaked or flooded by water at least part of the year.

ADVANCE PREPARATION

A. Gather all the materials needed for the “Wetland in a Bottle.”

B. Photocopy the student sheets “Wet What?” and “Plants, Animals, and Soils” for each student.

C. In order to simulate how wetland plants absorb pollution, put the freshly cut celery stalks in colored water 24 hours before the lesson (divide the stalks between 2 glass jars or beakers).

PROCEDURE

I. Setting the stage

A. Write the terms “Constructed Wetland” and “Natural Wetland” on the board.

1. Ask the students to define a wetland.
2. Write the definitions of the terms on the board.
3. Discuss the differences between constructed and natural wetlands.

B. Pass out the student sheet “Wet What?”

1. Ask volunteers to read aloud from “Wet What?”
2. Ask the students to write the definitions of constructed and natural wetlands on their papers.

C. Divide the class into teams and do the following:

1. Show the class the celery in the colored water.
2. Explain that the food coloring represents pollutants in wastewater.
3. Explain that the celery absorbs the colored water like some plants in a wetland absorb the pollutants in wastewater.
4. Give each team a stalk of celery.

a. Have each team cut the celery so everyone has a piece.

b. Have each student observe how the piece of celery shows absorption of the "pollution."

II. Activity

A. Having observed their pieces of celery, the students will write answers to the following questions on the back of their "Wet What?" student sheets.

1. If the food coloring represents pollutants, how does the celery represent a wetland plant? (It absorbs pollutants in the water.)

2. Was all the food coloring (pollutants) absorbed by the celery? (no) Explain why not. (Plants only absorb as much water as they need.)

B. Demonstrate a constructed wetland by building a wetland terrarium. (See the teacher sheet "Wetland in a Bottle.")

1. Explain step-by-step how to build the wetland as you build it.

2. Ask the following questions and discuss the answers with the students:

a. What absorbs the pollutants in our terrarium? (The plants soak up the pollutants.)

b. Where would a constructed wetland be beneficial? (to treat mine run-off, for failed septic tanks and field systems, for areas where septic tanks cannot be used, for small communities that cannot afford to build a conventional treatment plant, for industries and farm operations that cannot use a conventional plant)

III. Follow-Up

Divide the students into groups. Pass out the student sheet "Plants, Animals, and Soils," poster board or butcher paper, and art supplies.

A. Explain that each group will make a mural of a constructed wetland terrarium.

B. First, have them color soils and water as shown on the student sheet.

C. Next, have them color and cut out all the plants and animals.

D. Then, they will decide where to place their plants and animals on their piece of paper or poster board with the soils and water drawn on.

E. The students will complete their constructed wetland collage by drawing more plants and animals of their own to fill in. (Remind them that wetlands have lush vegetation.)

IV. Extensions

A. Students can research wetlands in encyclopedias, magazines, newspapers, and library books and give oral reports to the class.

B. Each student can imagine he/she is an animal who lives in a wetland and write a creative story about one day in his/her life.

RESOURCES

Breazeale, Janet, "What's in the Boxes? One Way of Handle Wastes," Inside TVA, Vol. 13, No. 15, Tennessee Valley Authority, Knoxville, Tennessee, 7/14/1992.

DeBruin, Jerry, Creative, Hands-On Science Experiences Using Free and Inexpensive Materials, Good Apple, Inc., Carthage, Illinois, 1986, p. 79.

McCarthy, Dennis, "The Wonders of Wetlands," Inside TVA, Vol. 13, No. 15, Tennessee Valley Authority, Knoxville, Tennessee, 7/14/1992.

"Natural Wetlands/Constructed Wetlands, (Factsheet)," Tennessee Valley Authority, October 1989.

Slattery, Britt Eckhardt, "WOW! The Wonder of Wetlands," Environmental Concern, St. Michael's, Maryland, 1991, p. 43.

WET WHAT?

Name ______________________________ Date ______________________

Swamps, marshes, bogs, and low pieces of land that stay soaked or flooded by water are natrual wetlands. Constructed wetlands are designed and built to treat wastewater from domestic, agriculatual, and mining activities.

In a constructed wetland, wastewater flows through a septic tank or other primary treatment and into the cell or compartment of the wetland. The bottom and sides o f the cell are covered with a waterproof liner to prevent leaks and to keep the water level even. Plants such as cattails and bulrushes absorb trace metals and other pollutants. Suspended solids and other trace metals settle to the bottom of the cell as sediment. The wastewater then flows into another cell, where it nourishes thick-growing wetland plants. Extra water soaks into the ground because the second cell is not lined. Water left over from this cell is clean enough to discharge.

Define the folowing:

Coastal wetlands -

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Natural wetlands -

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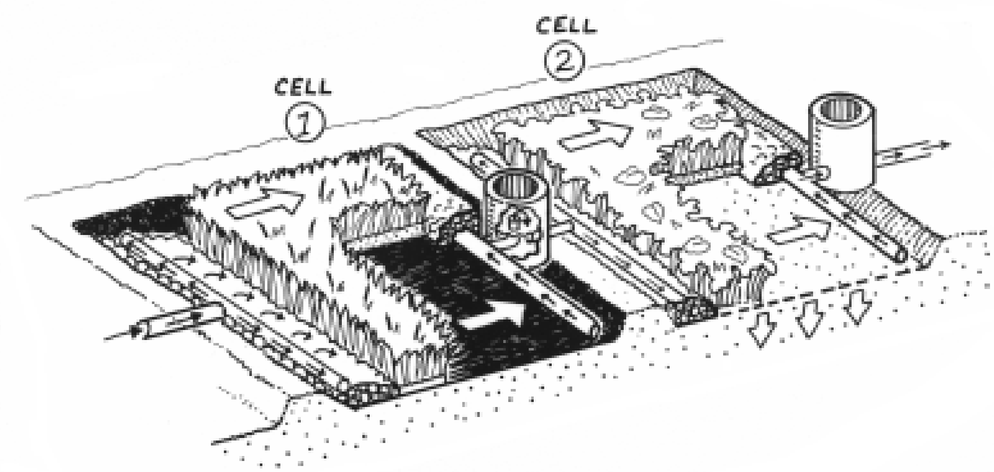
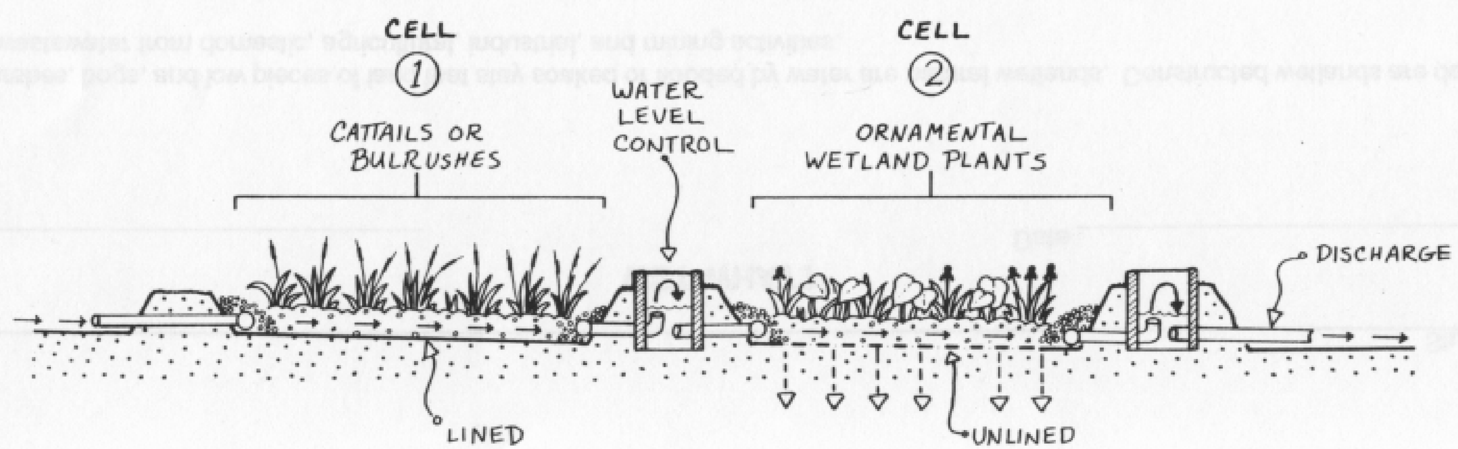
WET WHAT?
(continued)





WETLAND IN A BOTTLE

Gallon (4 L) jar with lid
Gravel
Sand
Soil
Sphagnum Moss
Humus
Water
Plants (such as Venus' flytrap, bladderwort, ferns)
Small Animals (such as salamanders, frogs, turtles)

(NOTE: If you use Venus' flytraps, you will need to add live flies. Also, if you use salamanders, frogs, or turtles, you will need to obtain the proper foods and feed them.)

The soil of a wetland is very moist and surface water can vary from shallow to deep. Our terrarium needs shallow water.

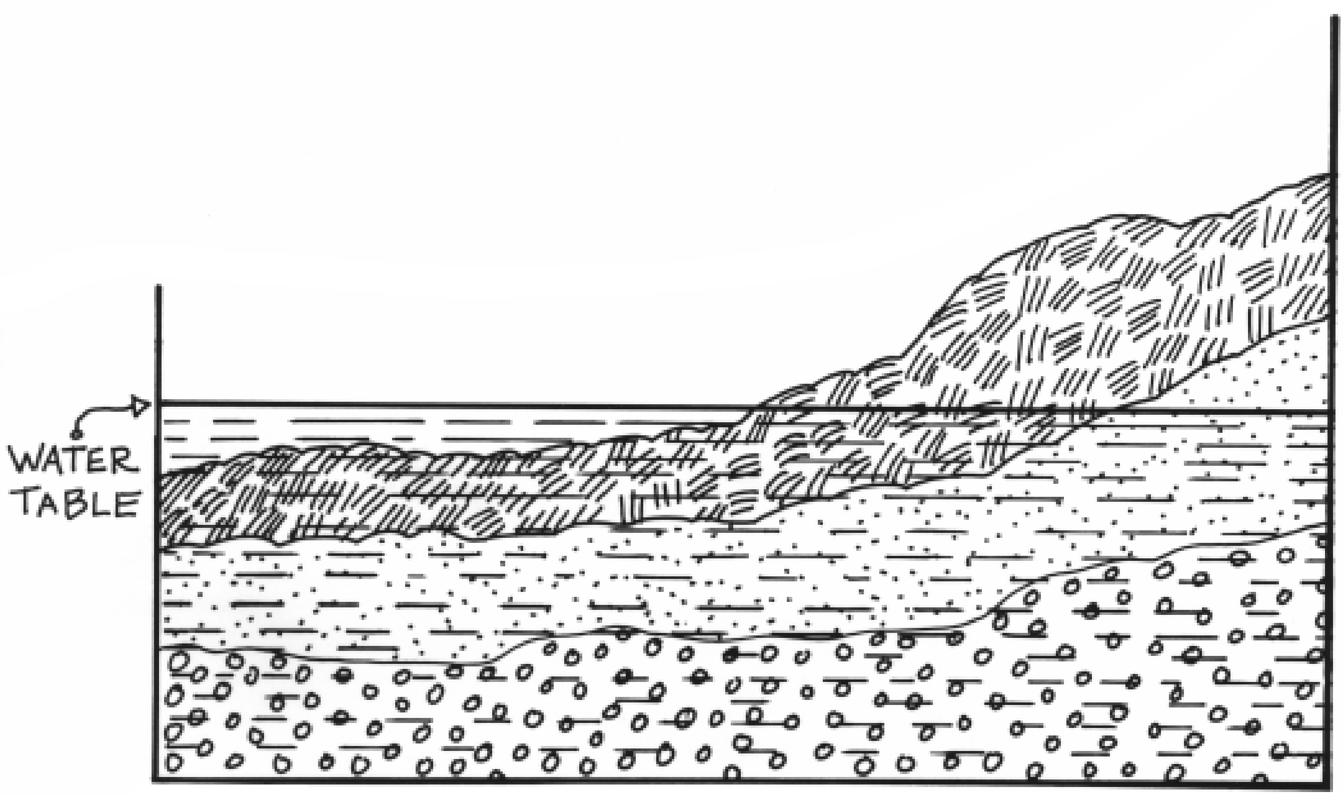
1. First add a layer of gravel.
2. Add a thin layer of sand and soil mixture.
3. Next, add a mixture of 2 parts sphagnum moss and one part humus in a thin layer.
4. Slope all the layers and the surface to make a low spot on one side.
5. Evenly space the plants.
6. Add water to the lowest level of soil.
7. Add animals last.
8. Then cover and place in a location with filtered sun.

PLANTS, ANIMALS, AND SOILS

Name ______________________ Date ______________________

To make a constructed wetland mural:

1. Draw a rectangle or jar shape on your group's butcher paper or poster board.
2. Color layers of soil as shown below.
   a. Gravel layer
   b. Sand layer
   c. Sphagnum moss and humus layer
3. Color in the water in the wetland.
4. Color and cut out plants and animals and glue them on the mural.
5. Draw in more of your own plants and animals.



PLANTS, ANIMALS, AND SOILS
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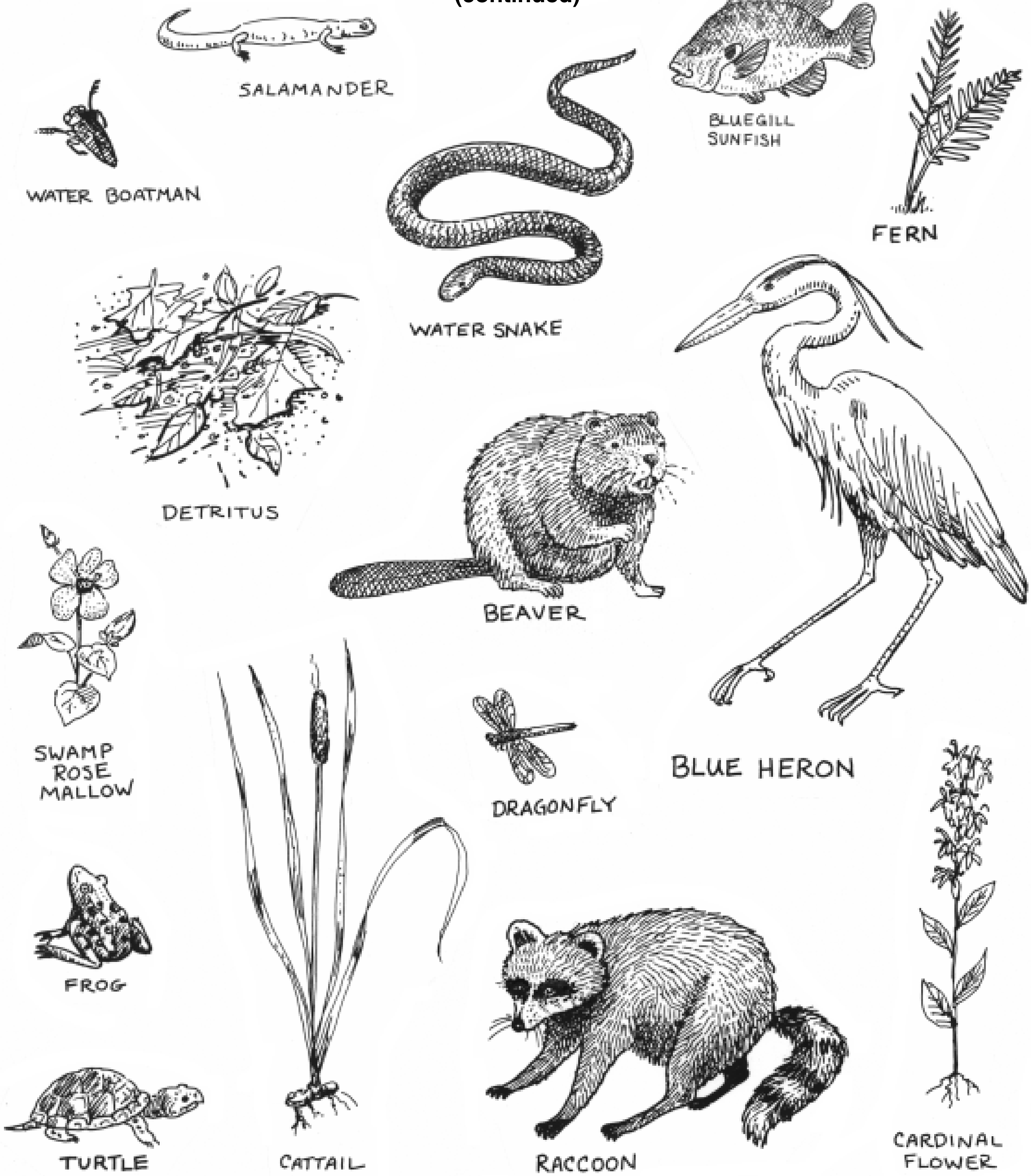


SETTLING THE WASTEWATER PROBLEM

OBJECTIVES

The student will do the following:

1. Name models that are representations of larger objects.

2. Suggest ways that industry, agriculture, and mining affect water quality.

3. Demonstrate the use of lagoons for treating wastewater.

SUBJECTS:
Science, Language Arts

TIME:
90 minutes

MATERIALS:
3 large jars
charcoal
6 smaller containers (such as small buckets)
ammonia
funnel or liter bottle with bottom cut off
pieces of wood
soil
paper towels
coffee grounds (or sterile gardening manure)
nylon hosiery
flour
medium rocks
vegetable oil
cotton balls
bleach
sand
iron filings
3 paper or plastic cups
small rocks
vinegar

BACKGROUND INFORMATION

Water pollution remains a serious problem in most parts of the United States. Sediment, nutrients, bacteria, and toxic material still find their way into the nation's waters where they damage ecosystems, cause health hazards, and prevent the full use of water resources.

In agriculture, all livestock operations face the growing concern of animal waste disposal. Animal wastes pollute the environment when not disposed of properly. Because of its nutrient value, animal waste should be viewed as a resource rather than as a waste. It provides the producer with a valuable soil conditioner and source of fertilizer. Animal waste doesn't have to be a pollution problem. A well designed and maintained waste management system benefits not only the producer, but the community as well.

Pollutants carried by runoff from such urban features as streets and roadways, commercial and industrial sites, and parking lots affect between 5-15 percent of surface waters. Urban runoff contains salts and oily residues from road surfaces and may include a variety of nutrients and toxic material as well.

Higher temperatures associated with industrial wastewater can result in "thermal pollution." Up to 10 percent of surface waters are adversely affected by acid drainage from abandoned mines, pollution from mill tailings, mining waste piles, and pollution from improperly sealed oil and gas wells.

All of these kinds of wastewater can be treated by allowing them to rest in settling/treatment ponds to clean the water for discharge.

Terms

groundwater: water that infiltrates into the earth and is stored in usable amounts in the soil and rock below the earth's surface; water within the zone of saturation.

lagoon: an animal waste treatment method which uses a deep pond to treat manure and other runoff from a livestock operation. Lagoons can be aerobic or anaerobic. Both use bacteria to break down materials.

model: a small representation of a larger object.

surface water: precipitation that does not soak into the ground or return to the atmosphere by evaporation or transpiration, and is stored in streams, lakes, wetlands, reservoirs, and oceans.

water treatment: the conditioning of water to make it acceptable for a specific use.

ADVANCE PREPARATION

A. Fill the 3 large jars (use gallon jars from the lunchroom) with clean water.

B. During the demonstration you will create models of agricultural, industrial, and mining wastewater by "dumping" the waste substitutes into the appropriate jar. Gather the following materials for the demonstration:

 1. To simulate agricultural wastewater, obtain 1 cup (250 mL) ammonia, 2 cups (500 mL) soil, and 2 cups (500 mL) used coffee grounds or sterile gardening manure for the substituted waste.

 2. To simulate industrial waste, obtain 1 cup (250 mL) flour, 1 cup (250 mL) vegetable oil, and 1 cup (250 mL) bleach.

 3. To simulate mining wastewater, obtain 2 cups (500 mL) soil, 1 cup (250 mL) iron filings, 1 cup (250 mL) small rocks, and 1 cup (250 mL) vinegar (for acidic smell). (NOTE: Iron filings are readily available from auto parts stores where they work on brakes; these are usually free.)

 NOTE: Take extra care to make sure ammonia and bleach aren't accidentally mixed. Mixing them can release poisonous chlorine gas.

C. Gather the other materials. Try to avoid giving the students glass containers.

PROCEDURE

I. Setting the stage

A. Divide the class into 6 teams. Tell members of the first two teams they represent farmers; the third and fourth teams represent manufacturers; and the fifth and sixth teams represent miners.

B. Each group should have a funnel and several items available to them to attempt to purify the wastewater. Suggested items might include charcoal, pieces of wood, paper towels, nylon hosiery, rocks (small and medium size), moss, cotton balls, or sand.

C. You will divide the 3 wastewater supplies in half. Each group should have a large jar or pitcher (or a small bucket) of its own.

D. Tell the teams not to touch the jars until they are ready. This helps avoid spills and accidents.

II. Activity

A. Explain and give examples of a model representing a larger object. (globe = earth, model car = vehicle, doll = baby)

1. Tell the students that it is sometimes impossible to show real objects (like the earth) because of their size.

2. Have them cite other examples to show comprehension.

B. Show one of the jars of clean water. Tell the students that this jar is a model that represents 1 million gallons of water that falls on a large farm with fields and cattle operation.

1. Ask the students to suggest ways the water could become polluted. (runoff from animal waste, fertilizer, etc.)

2. Simulate the agricultural wastewater by "dumping" in the agricultural pollutants to make wastewater.

3. Explain what each pollutant represents: The ammonia represents animal urine. The soil represents eroded topsoil, and the coffee grounds or gardening manure represents solid animal waste.

4. Divide the agricultural wastewater between the 2 groups of "farming representatives," leaving about 1/3 of it for a further demonstration.

C. Select another jar of clean water. Tell the students that this jar is a model that represents 1 million gallons of water that flows from a manufacturing plant.

1. Ask the students to suggest ways the water could become polluted. (dumping, cleaning, mixing chemicals)

2. Simulate the industrial wastewater by "dumping" the industrial pollutants into the second jar. Explain what each pollutant represents: The flour represents biological wastes like paper pulp; the oil represents wastes like lubricating (motor) oil; and the bleach represents, and is very similar to, chemicals used by many factories.

3. Divide the industrial wastewater between the 2 groups of "manufacturing representatives," leaving about 1/3 of it for a further demonstration.

D. Select the third jar of clean water. Tell the students that this jar is a model that represents 1 million gallons of water that flows from a mine.

1. Ask the students to suggest ways the water could become polluted. (runoff, washing equipment, washing work clothes, etc.)

2. Simulate the mining wastewater by "dumping" the mining pollutants into the jar. Explain what each pollutant represents: The soil and rocks obviously represent the tons of earth material disturbed by mining; the iron filings represent the minerals exposed by mining; and the vinegar represents the acids that can leach from rocks dug up by mining.

3. Divide the mining wastewater between the 2 groups of "mining representatives," leaving about 1/3 of it.

E. Explain that the different land uses represented are necessary for us to live our lives the way we do, but the by-products of the activities represented in each of the three jars is the same: it is called “wastewater.”

   1. Ask that students the following questions. (NOTE: Remind the students that their jars each represent 1/2 million gallons of water.)

      a. Would you drink this water?

      b. Would you dump this water into the river or lake?

      c. If you dumped this water down a drain, where would it go?

   2. Tell the teams they must find a way to make the wastewater reusable since there is so much of it. Take the class outside; this is a messy process.

      a. They are to use the materials available and attempt to remove as much of the odor and pollutants as possible using paper cups and smaller containers provided. (CAUTION: Containers may become slippery when wet.)

      b. Allow the students to work on their own in their teams for about 15-20 minutes. Supervise for safety.

F. Let representatives from each team explain their processes and results.

G. Explain that there is another treatment method (if no one mentions it) that is less expensive and more feasible called a “holding pond” or lagoon.

H. Label each jar (agriculture, mining, and industry). Demonstrate the lagoon by allowing each jar to sit undisturbed overnight. (This allows settling to occur.)

   1. Allow the students to observe and smell each jar after 24 hours.

   2. Discuss the differences in the appearance of the wastewater.

III. Follow-Up

A. Compare the various methods the groups used to treat wastewater with the lagoon method.

   1. Ask which method would be less expensive to treat large amounts of wastewater. (lagoon)

   2. Ask which method would be easier to use with large amounts of wastewater. (lagoon)

   3. Ask the students what else needs to be considered before the wastewater could be of better quality. (get rid of pollutants that did not settle—like smell and color)

   4. How could the water from lagoons be used? (irrigation, discharge into streams, etc.)

B. Have each group write a report of their wastewater treatment results.

   1. What products did not settle?

   2. Which team's jar settled the most?

3. Which group would benefit the most from using a lagoon as a water treatment process?

4. How could the processed water be used?

C. Dispose of the simulated lagoons by pouring the water off the settled solids. Allow the jars to dry and, then dispose of the dry material in the trash, and wash out the jars for reuse.

IV. Extension

A. Visit a wastewater treatment plant.

B. Plan a field trip to a large farm, manufacturing plant, or a mining area that utilizes a lagoon.

C. Have a representative from each category above visit the classroom and discuss using a lagoon as a treatment method.

RESOURCES

Environmental Resource Guide: Nonpoint Source Pollution Prevention (Grades 6-8), Air & Waste Management Association, Pittsburgh, Pennsylvania, 1992.

EPA Journal Vol. 17, No. 5, U.S. Environmental Protection Agency, Washington, DC, November/December 1991.

Leopold, Luna, Water Use and Development, U.S. Government Printing Office, Washington, DC, 1960.

"Nonpoint Source Pollution" (Water Quality Factsheet #4), Tennessee Valley Authority, 1988.

WASTE NOT, WANT NOT

OBJECTIVES

The student will do the following::

1. Simulate the uses and conservation of water.

2. List 3 to 5 ways to conserve water.

3. Recognize wasteful uses of water in their own environments.

SUBJECTS:
Math, Ecology, Science, Language Arts, Conservation

TIME:
45-90 minutes

MATERIALS:
two 2-gallon (8 L) buckets
2 measuring cups
"Water Use" cards (included)
student sheets (included
teacher sheet (included)
ruler
scissors
glue
crayons or markers
heavy construction paper
brass paper fasteners

BACKGROUND INFORMATION

At this very second, somewhere on the earth, water is falling as snow, rain or sleet. Nature provides us with so much water that if all the mountains and hills were leveled, water would completely cover the earth to a depth of nearly 2 miles (3.2 km). Despite this abundance, water does not fall evenly over the earth's surface. Where precipitation supplies too little water, the result can be desolation. Organisms in a dry environment must be specially adapted to minimize their need for water. Liquid water is the most important single substance for life on earth. Some bacteria live without oxygen, but all known life forms require water.

Water makes up more than 70 percent of all living things. It is found in almost everything we see and touch. The use of water is required by almost every kind of economic activity. It is indispensable to our lives. Water is a natural resource that must be used wisely.

Term

conservation: the act of keeping, protecting, or preserving our natural resources.

ADVANCE PREPARATION

A. Prepare ahead of time by bringing two 2-gallon buckets (or similar containers). Label one "Water Supply" and one "Water Used." Fill the bucket labeled "Water Supply" with water.

B. Duplicate and cut out the water use number and letter cards (teacher sheets).

C. Make photocopies of the water conservation quiz (one per student).

PROCEDURE

I. Setting the stage

A. Have the students discuss all the various ways they use water in a single day.

1. List them on the board and encourage them to include ways that water is used indirectly (e.g., farming, manufacturing, food processing).

2. Categorize the list by having the students decide if the usage is play, work, or home.

B. Assign two students to special positions: one will be a recorder and the other will measure the amount of water used (this person will be the "Quantity Control Officer").

C. Show the students the bucket labeled "Water Supply." Measure the depth of water in the bucket with a ruler and have the "recorder" write the results on the board. Tell the students that the bucket labeled "Water Supply" represents the amount of fresh water allowed per day for the group.

D. Explain that in this simulation, there will be a Group 1 and a Group 2. (NOTE: This simulation is designed for 24 students. The number of participants can be varied as needed. Make sure there is an equal number of conserver and nonconserver cards.)

II. Activity

A. Divide the class into 2 groups.

B. Pass out the "Water Use Number Cards" to Group 1 and the "Water Use Letter Cards" to Group 2. Explain that these cards represent how much water each person will use in a day.

1. Begin with Group 1.

2. As each student reads his demand on the water supply aloud, the "Quantity Control Officer" should remove that amount of water from the water supply bucket and place it in the bucket labeled "Water Used."

3. Ask the student who has card number 1 to read his/her demand and the amount of water needed. Continue with subsequent numbers.

4. This process should continue until all the number cards are used.

C. Measure the depth of water left in the "Water Supply" bucket. Have the recorder write the results on the board.

D. Subtract the amount of water left from the starting amount. Record the difference for Group 1.

E. Repeat the process for Group 2, beginning with the same amount of water as before. (NOTE: If none of the water has been spilled, dumping the used water back into the first bucket should be equal to the same amount.)

1. Ask the student who has card A to read his/her demand and the amount of water needed. Continue with subsequent letters.

2. This process should continue until all the letter cards in the group are used.

F. Measure the amount of water left in the "Water Supply" bucket and record as before.

G. Subtract the amount of water left from the starting amount. Record the difference for Group 2.

H. Discuss the noticeable difference between the amounts left and have the students formulate explanations.

I. Interject the "Water Trivia" teacher sheet; share selected facts with the students.

III. Follow-Up

A. Have the students state the difference in the groups; they should notice how one group carefully used its water supply and the other used it without concern for the amount available.

B. Help the students explain the differences in behaviors in the water use by each group.

C. Ask the students how group 1 could have conserved more.

D. What things do the students do that could conserve water in their daily uses?

E. Have the students list 3 to 5 ways to conserve water.

F. Have the students complete the student sheet, "Water Conservation Quiz." (Answers: 1.W, 2.W, 3.W, 4.S, 5.S, 6.S, 7.S, 8.S, 9.W, 10.W)

IV. Extensions

A. Give the students copies of the "Water Use Detective Badge and Citation" student sheet. Have them color and cut out the badge; they can pin or tape it to their shirts. Have the students become "Water Use Detectives" by finding as many ways as possible the school wastes water. Make a list of their findings and suggested solutions on the citation. Post these lists or send them to the principal.

B. Have the students complete a checklist of conservation improvements and practices in their individual homes as a homework assignment.

C. Have the students categorize the teacher sheet information (trivia) and student water use suggestions as to whether they are home, work, or play uses. Design circle, bar, or line graphs to show the results.

D. Have the students write a letter to the local newspaper explaining their concerns to the public.

RESOURCES

"The ABC's of Water Conservation," Channing L. Bete Company, New York, 1981.

Burch, Sandra K., "Be Water-Wise," Virginia Water Resource Center, Blacksburg, Virginia, 1983.

Leopold, L. and W. Langhein, A Primer On Water, U.S. Government Printing Office, Washington, DC, 1960.

"The Story of Drinking Water: Teacher's Guide Primary Level," American Water Works Association, Denver, Colorado, 1984.

WATER USE NUMBER CARDS

Group 1

#1 I have been working in the sun and am very thirsty. I would like some cold water to drink. 1 CUP (250 mL)	#2 I have been playing basketball and need to take a bath. 3 CUPS (750 mL)
#3 Mom asked me to wash the breakfast dishes, so I put them in the dishwasher and turned it on. 2 CUPS (500 mL)	#4 Mom said my tennis shoes need cleaning, so I ran them through the washing machine. 2 CUPS (500 mL)
#5 Since it's so hot outside, I want to fill up the wading pool. 2 CUPS (500 mL)	#6 It is time for lunch and I need to wash my hands with the faucet running. 1 CUP (250 mL)
#7 Mom wants me to wash her car tonight. 2 CUPS (500 mL)	#8 Flush the toilet, please. 1 CUP (250 mL)
#9 Dad and I are growing a garden. Since plants need water, turn the sprinkler on, please. 2 CUPS (500 mL)	#10 I just ate an ice cream cone. I need to brush my teeth with the faucet running. 1 CUP (250 mL)
#11 Our grass needs water to grow every day. 1 CUP (250 mL)	#12 I noticed the faucet leaking but it's nothing more than a drip. 1 CUP (250 mL)

WATER USE LETTER CARDS

Group 2

A. I have been working in the sun and am very thirsty. There is a cold bottle of water in the refrigerator. 1/2 CUP (125 mL)	B. I have been playing basketball and I need to take a short 5-minute shower. 1/2 CUP (125 mL)
C. Mom asked me to wash the breakfast dishes. I will wait until our dishwasher is full. 1/2 CUP (125 mL)	D. Mom said my tennis shoes need cleaning. I'll run them in the washing machine when it is full of old towels or cleaning rags. 1 CUP (250 mL)
E. Since it is so hot outside, I want to fill the wading pool, but I don't need to fill it to the top. 1 CUP (250 mL)	F. It is time for lunch and I need to wash my hands. I'll just fill the sink halfway and not run the faucet. 1/2 CUP (125 mL)
G. Mom wants me to wash her car, so I'll use the water I saved from the kitchen and bathroom sinks instead of letting the water run down the drain. 0 CUPS (0 mL)	H. Please flush the toilet. There is a plastic bottle filled with stones in the tank. 1 CUP (250 mL)
I. Dad and I are growing a garden. We use a soaker hose and mulch the plants. I'll also use rainwater we have saved. 1/2 CUP (125 mL)	J. I just ate an ice cream cone. I need to brush my teeth. I never leave the water running. 1/2 CUP (125 mL)
K. Our grass needs water to grow, but not every day. We use a soaker hose. 1/2 CUP (125 mL)	L. I noticed the faucet leaking so I told my dad and he fixed it. 0 CUPS (0 mL)

WATER TRIVIA

1. It takes 100,000 gallons (379,000 L) of water to manufacture one automobile.
2. 122 gallons (462 L) of water are needed to produce one loaf of bread.
3. It takes 50 glasses of water to grow 1 glass of orange juice.
4. 97 percent of all earth's water is salty; only 3 percent is fresh water.
5. 3/4 of the earth's surface is covered with water.
6. A 20-minute shower uses 16-20 gallons (60-75 L) of water.

   A 10-minute shower uses 8-10 gallons (30-38 L) of water.

   A 5-minute shower uses 4-5 gallons (15-19 L) of water.
7. It takes 3 gallons (11 L) of water to flush a toilet.
8. It takes 30-40 gallons (115-150 L) of water for a tub bath.
9. 10 gallons (38 L) of water is required to hand wash dishes.
10. It takes 20-30 gallons (75-115 L) of water to run a washing machine.
11. The average American home uses an average of 293 gallons (1,110 L) of water a day.
12. It takes 2,500 gallons (9,500 L) of water to produce one pound (2.2 kg) of beef.

WATER CONSERVATION QUIZ

Saving or Wasting

Print an "S" on the line before an action that saves water. Print a "W" on the line before an action that wastes water.

____ 1. Take long showers.

____ 2. Fill the bathtub full.

____ 3. Delay fixing a leaky faucet.

____ 4. Fix a leaky toilet.

____ 5. Wash only full loads in the washing machine or dishwasher.

____ 6. Fill the bathtub 1/4 full.

____ 7. Turn off water while brushing teeth.

____ 8. Fix leaky faucet.

____ 9. Wash a few clothes every day.

____ 10. Let water run while brushing teeth.

Water Waste *CITATION*

Location of water waste ______________________________

____

Description ______________________________

____

Suggested solution(s) ______________________________

____

____

____

____

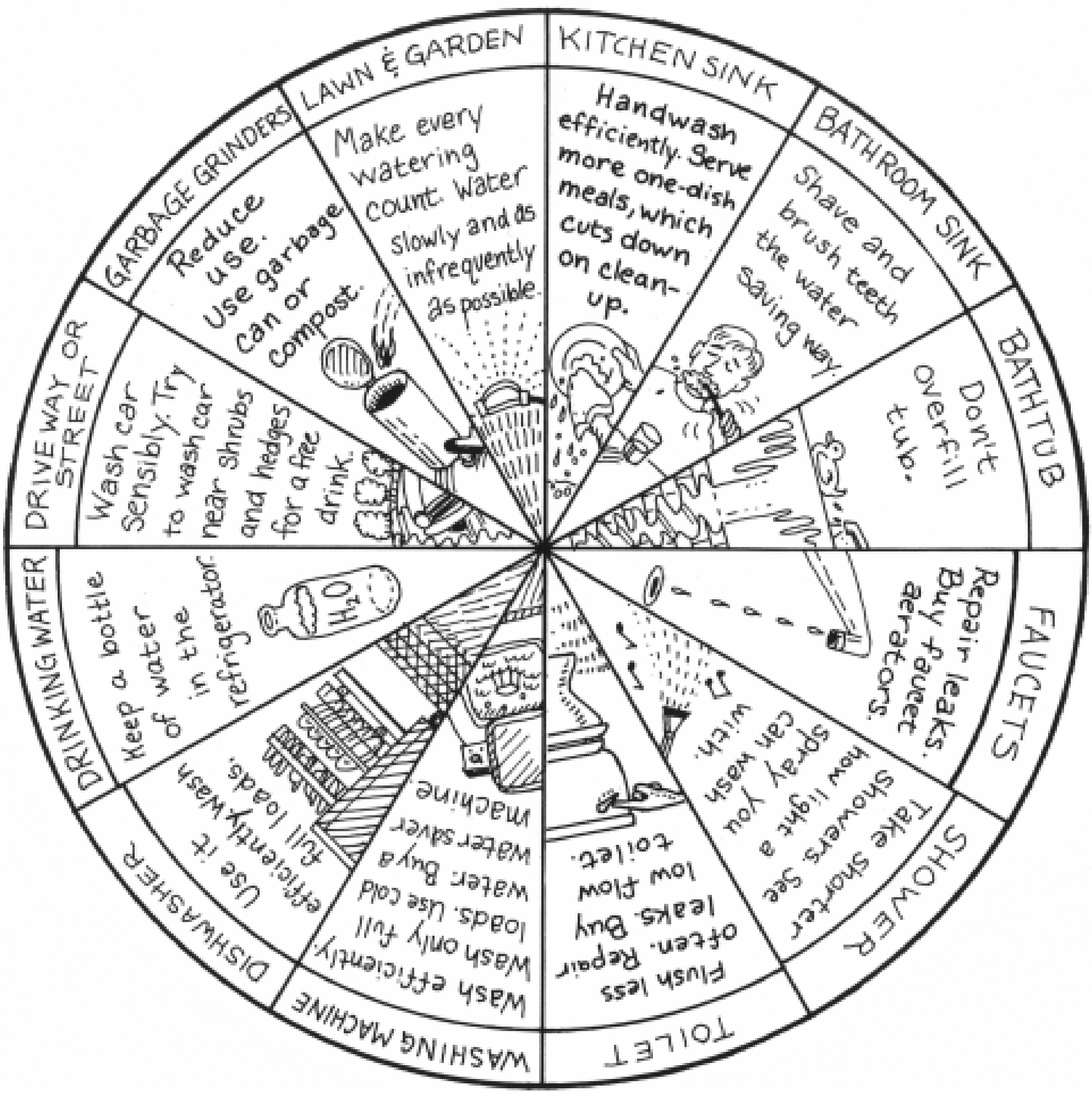
____

____

Issued by Officer ______________________________
(name)

Date ______________

MAKE A WATER CONSERVATION WHEEL!



MAKE A WATER CONSERVATION WHEEL!
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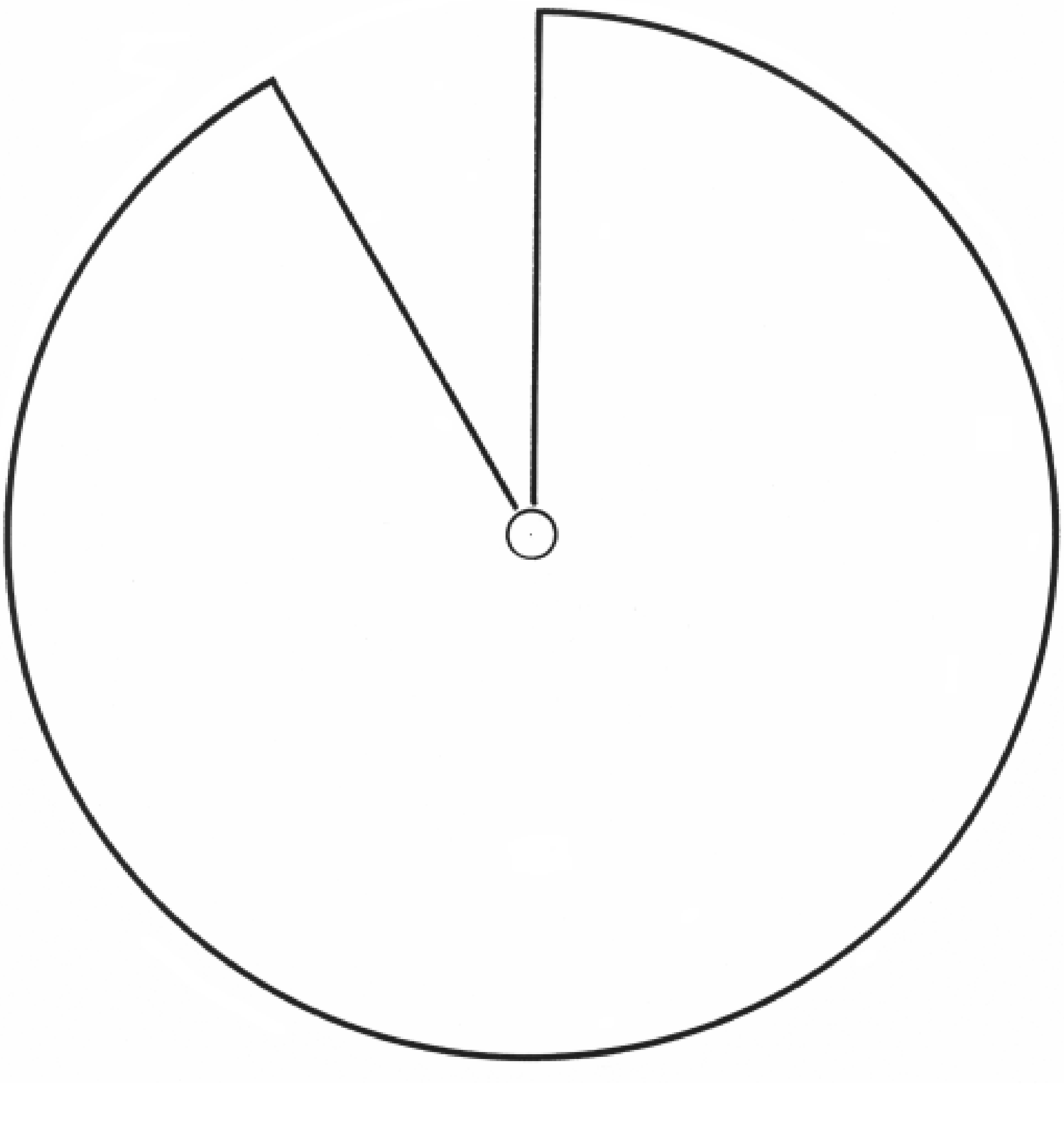


WATER PATROL

OBJECTIVES

The student will do the following:

1. Become aware that there are laws enacted and enforced to protect people's health and safety.

2. Demonstrate, through role play, different laws or acts that protect the health and safety of citizens.

SUBJECTS:
Science, Social Studies, Health, Language Arts

TIME:
45-90 minutes

MATERIALS:
hat or badge to represent police or fireman
posterboard or construction paper
markers
stapler
student sheet (included)
teacher sheet (included)

BACKGROUND INFORMATION

Most of us take safe, clean drinking water for granted. Prior to the passage of the Safe Drinking Water Act in 1974, the protection of public water supplies in the United States was guided by drinking water standards developed by the United States Public Health Service. Congress enacted the Safe Drinking Water Act in 1974 to ensure safe public drinking water. This law was amended in 1986 to expand the Environmental Protection Agency's role in protecting public health from contaminated drinking water. The amendments require the Environmental Protection Agency to:

1. Control specific disease-causing organisms and indicators of their presence in drinking water.

2. Require public water supply systems that use surface water sources such as lakes to filter their water unless it is established that their sources are very clean and well protected.

3. Require public systems to disinfect their water, unless the water comes from sources that are not at risk from microbiological contamination.

The Safe Drinking Water Act is primarily enforced by the states. Therefore, it is the responsibility of the local water supply system, the states, and the federal government to provide clean, safe drinking water to the public.

<u>Terms</u>

Environmental Protection Agency (EPA): the U.S. agency responsible for efforts to control air and water pollution, radiation and pesticide hazards, ecological research, and solid waste disposal.

groundwater: water that infiltrates into the earth and is stored in usable amounts in the rock and soil below the earth's surface; water within the zone of saturation.

Safe Drinking Water Act: a regulatory program passed by the U.S. Congress in 1974 to help ensure safe drinking water in the United States; sets maximum contaminant levels for a variety of chemicals, metals, and bacteria.

waterborne disease: a disease spread by contaminated water.

ADVANCE PREPARATION

A. Gather materials for the role playing. You may make hats or badges from poster board and/or construction paper to represent different people who enforce rules or laws (policemen, fireman, principal, mayor, governor, etc.).

B. You may also use toy badges or hats that represent these persons if they are available.

C. Make photocopies of the student sheet, "Cause and Effect," for each student.

PROCEDURE

I. Setting the stage

A. Ask the students the following questions:

1. What are laws? (any rule or principle that must be obeyed; relate to school rules that must be followed in the school environment)

2. Why do we have laws or rules that we must obey? (to protect people)

3. Give an example of a law or rule being broken. (e.g., exceeding the speed limit) Is this dangerous? (yes) Why? (It affects the safety of the driver and others.)

4. Who enforces the law?

a. On the local level, the mayor and those persons acting under his orders.

b. On the state level, the governor and those agencies that are under his jurisdiction.

c. On the federal level, the president and those agencies that are established for specific laws.

B. Share with the students the following information:

We only have to look around us to see the effects of rules or laws. We can see rules or laws being observed in our schools, in our community, and throughout our environment.

1. What do you think would happen if we had no rules in our school? (We would not be able to do our work, and/or it would not be safe.)

2. What do you think would happen if we had no rules or laws in our community? (People might not respect others' rights and our environment would not be a very safe or happy place to live; accept any answer.)

II. Activities

A. Have the students demonstrate laws being broken by role-playing "cops and robbers."

1. Have the students prepare a list of rules or laws that would protect their health or safety.

2. Have each student act out or role play (using props such as hats) one of the law breaking situations they have listed.

3. Ask the classmates to try to guess what rule or law is being portrayed. The first student to guess the rule or law being acted out, will role play the person who enforces that law and "arrest or reprimand" that person who has broken a law or rule.

4. Continue this process until all students have participated. (You may want to set a time limit for each student.)

B. Discuss with the students what laws or rules are being represented in each situation. Tell the students that they have a responsibility as a citizen to help to see that laws and rules are followed. Ask what they might do as citizens to help enforce the laws. (report wrongdoing they observe to the proper person who enforces the laws or rules)

C. Share the background information with the students. Emphasize that drinking water must be very clean or people could get sick. Ask the students to apply what they have learned about protecting er supplies and enforcing laws to ensure their water is safe to drink. Ask them these questions:

1. What can you do? (never pollute water in streams; report to proper authorities if you observe anyone dumping pollutants into drains, streams, and other bodies of water; accept any reasonable answer)

2. What law protects your drinking water? (the Safe Drinking Water Act)

3. Who enforces the Act? (the Environmental Protection Agency and the states)

4. What should you do if you suspect your water supply is contaminated? (You can contact your local water treatment plant or water utility to find out what steps you should take to have your water tested for contaminants. The address of your local facility will be on your bill.)

5. For detailed information, contact your local water treatment facility or health department. Ask them how they comply with the Safe Drinking Water Act.

III. Follow-Up

A. Have the students complete the student sheet, "Cause and Effect." (Answers: 1-c; 2-a; 3-f; 4-b; 5-c; 6-d.)

B. Have the students write a paragraph explaining why we have laws.

IV. Extensions

A. Have the students choose one of the following topics, look up its danger to drinking water, and write a report on how each could contaminate drinking water. Younger students might depict these on "mini-murals" (large construction paper sheets).

1. Landfills

2. Underground storage tanks

3. Hazardous waste

B. Contact your senator, congressman, or local state representative and ask what bills have been offered in the legislature to protect drinking water standards and groundwater in your state.

RESOURCES

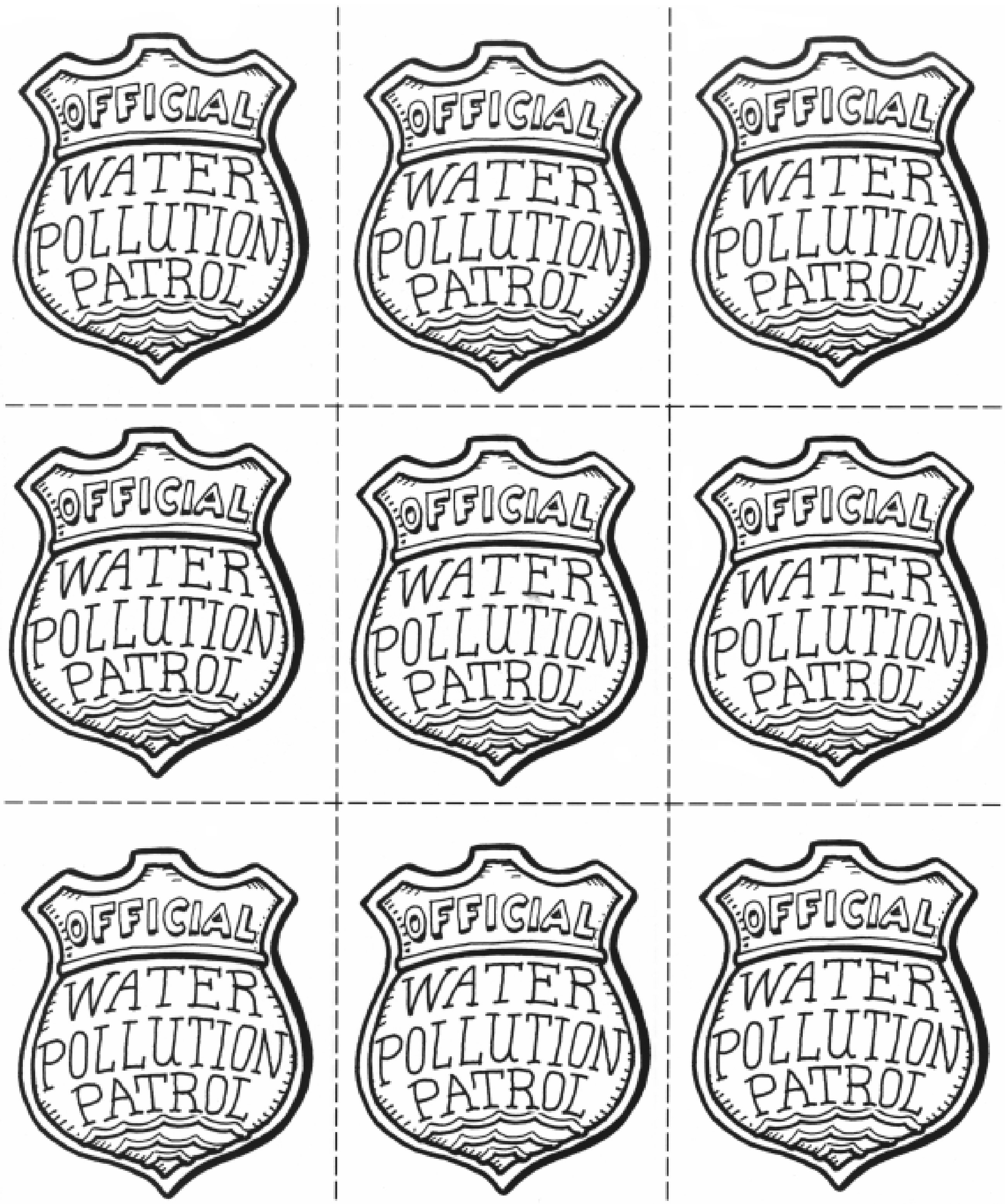
Jorgensen, E. P., ed., The Poisoned Well: New Strategies for Groundwater Protection, Island Press, Washington, DC, 1989.

"Protecting Our Drinking Water from Microbes," U.S. Environmental Protection Agency, Washington, DC, 1989.

CAUSE AND EFFECT

Match the causes and effects.

Causes	**Effects**
1. Pour oil in drainage ditch	a. Serious damage to brain, kidneys, and nervous system
2. High concentration of lead in drinking water	b. Ensures clean drinking water to protect public health
3. Contaminated surface and groundwater	c. Stronger, healthier teeth
4. Safe Drinking Water Act	d. Sets national standards and monitors water supply operators
5. Adding fluoride to drinking water	e. Groundwater contamination
6. Environmental Protection Agency	f. Waterborne diseases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